JUL 31 1922

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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See Illustrated Advertisement Page 100, Jan. 28, 1921.

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See page 17, July 14. 9947

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See Advertisement Page 26.

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See Advertisement page 56, July 14. 2409

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See half-page Advertisement page 38, July 7.

See Advt. Page 76 July 14.
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TENDERS.

THE BURMA RAILWAYS COMPANY, LIMITED.

The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

Tenders for the Supply of :—

(A) 446 COVERED GOODS WAGONS (4-wheeled).
60 QUADRUPLE BOLSTER WAGONS (Bogie).
10 GOODS BRAKE VANS (4-wheeled).
(B) 1153 PAIRS of WHEELS and AXLES.

For each copy of the Specification (A) a fee of £2 will be charged, and for each copy of the Specification (B) a fee of £1 will be charged, which fees are not returnable. Tenders enclosed in sealed envelopes endorsed "Tender for Wagons," or "Tender for Wheels and Axles," as the case may be, must be delivered at the Company's Offices not later than Twelve noon on Tuesday, 15th August, 1922. The Directors do not bind themselves to accept any or the lowest Tender, and reserve the right to divide the order.

By Order of the Board,
F. C. FRANKS,
Secretary.

100, Gresham House,
Old Broad Street,
London, E.C. 2.
20th July 1922. U 815

NEW SOUTH WALES, AUSTRALIA.

SYDNEY HARBOUR BRIDGE.

Intending Tenderers are Here-

by Notified that the TIME for receipt of Tenders for the construction of the Superstructure and Substructure of a Cantilever Bridge across Sydney Harbour has been EXTENDED by the New South Wales Government until 1st SEPTEMBER, 1923.

T. A. COGHLAN,
Agent-General for New South Wales.
Australia House,
London, W.C. 2.
14th July, 1922. U 797

METROPOLITAN WATER BOARD.

TENDERS FOR THE SUPPLY AND ERECTION OF DIESEL OR HIGH COMPRESSION SOLID INJECTION ENGINES WITH WELL AND SURFACE PUMPS AT HYNSFORD, KENT.

The Metropolitan Water Board Invite

Tenders for the Supply and

ERECTION of TWO DIESEL or HIGH COMPRESSION SOLID INJECTION OIL ENGINES of approximately 230 B.HP. each, with well and surface pumps, etc., at their Hynsford Works, Kent.

Forms of Tender, Conditions of Contract, Specification and Drawing may be inspected, without payment of fee, at the Offices of the Board (Room 182), Chief Engineer's Department, 173, Rosebery Avenue, Clerkenwell, E.C. 1, on and after Monday, 24th July, 1922. Contractors desirous of tendering may obtain the necessary documents from Mr. HENRY E. STILGOE, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of £3 3s., which sum must be deposited with the Board's Accountant, and will be returned on receipt of a *bona fide* Tender, together with all incidental papers. Such payments and applications must be made between the hours of Ten a.m. and Four p.m., Thursdays excepted (Saturdays Ten a.m. and Twelve Noon).

Tender, enclosed in sealed envelopes, addressed to "The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, E.C. 1," and endorsed "Tender for Machinery, Hynsford," must be delivered at the Offices of the Board not later than Ten a.m. on Wednesday, 13th September, 1922.

W. MOON,
Clerk of the Board.

Offices of the Board,
173, Rosebery Avenue, E.C. 1.
18th July, 1922. U 823

METROPOLITAN WATER BOARD.

TENDERS for the SUPPLY and ERECTION of PUMPING MACHINERY, Surbiton Pumping Station, Surrey.

The Metropolitan Water Board invite

Tenders for the Supply and

ERECTION at their Surbiton Pumping Station, Surrey, of ONE STEAM TURBINE with Centrifugal Pumps, having a maximum capacity of 20 million gallons per 24 hours.

Forms of Tender, Conditions of Contract, Specification and Drawings may be inspected, without payment of fee, at the Offices of the Board (Room 182), Chief Engineer's Department, 173, Rosebery Avenue, Clerkenwell, E.C. 1, on and after Friday, 21st July, 1922.

Contractors desirous of tendering may obtain the necessary documents from Mr. HENRY E. STILGOE, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of £3 3s., which sum must be deposited with the Board's Accountant, and will be refunded on receipt of a *bona fide* Tender together with all incidental papers. Such payments and applications must be made between the hours of Ten a.m. and Four p.m. (Thursdays and Saturdays excepted).

Tenders, enclosed in sealed envelopes addressed to "The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, E.C. 1," and endorsed "Tender for Steam Turbine and Pumps, Surbiton," must be delivered at the Offices of the Board not later than Ten a.m. on Wednesday, 13th September, 1922.

The Board do not bind themselves to accept the lowest or any Tender.

W. MOON,
Clerk of the Board.

Offices of the Board,
173, Rosebery Avenue,
E.C. 1.
17th July, 1922. U 807

ABERDEEN CORPORATION WATER WORKS.

EXTENSIONS, 1920.

CONTRACT No. 6—NEW AQUEDUCT.

The Town Council of Aberdeen are prepared to receive

Tenders from Competent

Persons willing to enter into a Contract for the MANUFACTURE and DELIVERY of about two miles of 4 feet diameter PIPES and SPECIALS of the following alternative types, viz :—

(A) Cast Iron.
(B) Mild Steel.
(C) Reinforced Concrete — Bonna and Centrifugal Types.
(D) Reinforced Concrete—Ordinary Type.

The Drawings may be inspected and Specification, Schedules of Quantities and Forms of Tender obtained, on and after 24th July, 1922, on application at the Water Engineer's Office, 41½, Union Street, Aberdeen.

For each Specification of each type a deposit of £5 sterling will be required, which sum will, after a Tender has been accepted, be returned to the Tenderer, provided that he shall have sent in a *bona fide* Tender, based on the Drawings, Specification and Schedule of Quantities provided, with the Schedule of Quantities fully priced out in detail, and shall not have withdrawn the same.

Tenders on the Forms prescribed and enclosed in securely sealed envelopes, endorsed "Tender for New Aqueduct" and addressed to the Undersigned, must be delivered not later than Ten a.m. on the 7th August, 1922.

The Town Council do not bind themselves to accept the lowest or any Tender.

GEORGE MITCHELL, M.Inst.C.E.,
Water Engineer.

Water Engineer's Office,
41½, Union Street, Aberdeen.
13th July, 1922. U 817

COUNTY BOROUGH OF BOURNEMOUTH.
(AMENDED ADVERTISEMENT.)

Tenders are Invited for New

DECK JOISTS, DECKING, etc., required on the Bournemouth Pier.

Form of Tender, Conditions, Specification and Bill of Quantities, can be obtained of the Borough Engineer, Mr. F. P. DOLAMORE, at whose office the drawings can be seen, on or after Monday morning, the 10th July, 1922, provided the sum of £1 1s. has been previously deposited in respect of each Tender with the undersigned, which deposit shall become forfeited unless a Tender complying with the conditions be sent in.

Sealed Tenders are to be forwarded in special envelopes which will be furnished for the purpose, to the Town Clerk, Town Hall, Bournemouth, not later than Noon on Saturday, 2nd September, 1922.

The Council do not bind themselves to accept the lowest or any Tender.

F. P. DOLAMORE, F.S.I.,
Borough Engineer & Surveyor.

Town Hall,
Bournemouth.
4th July, 1922. U 723

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of :—

PUMP AND FILTER HOUSE for the Water Supply of the Trichinopoly Workshops Scheme.
(Constructural Steelwork)

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Pump and Filter House," must be left with the undersigned not later than Twelve Noon on Friday, the 11th August, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10/- for each copy of the Specification.

Copies of the Drawings may be obtained at the Office of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W. 1.
20th July, 1922. U 823

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely :—

No.		Fee for Specification.
1.	Steel Chairbolts	7s. 6d.
2.	Brass Sheets, Copper Tubes, &c.	£1
3.	Copper Plates, Rods and Ingots	£1
4.	Ropes, Twines, &c.	10s.
5.	Sieves, &c.	7s. 6d.
6.	Lamps and Fittings	10s.
7.	Lamp Glasses	7s. 6d.
8.	Wicks, Lubricating Pads, &c.	7s. 6d.
9.	Stationery, &c.	10s.

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Steel Chairbolts," or, as the case may be, not later than Eleven o'clock a.m. on Tuesday, the 1st August, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 19th July, 1922. U 834

APPOINTMENTS OPEN.

THE RESEARCH ASSOCIATION OF BRITISH MOTOR AND ALLIED MANUFACTURERS,
15, Bolton Road,
Chiswick, W. 4.

Senior Research Assistants

REQUIRED, preferably with experience of Automobile research. Salary £500—£600 according to qualifications.
Apply by letter to the SECRETARY. U 812

THE BRITISH CAST IRON RESEARCH ASSOCIATION.

APPOINTMENT OF DIRECTOR OF RESEARCH.

The Council invite

Applications for the Post of

DIRECTOR OF RESEARCH to the Association at a commencing Salary not exceeding £900 per annum, according to Scientific attainments, and Foundry, Blast Furnace or other suitable Industrial experience.

Forms of Application can be obtained from the undersigned, which are to be returned on or before August 31st, 1922.

THOS. VICKERS,
Secretary.

Central House,
New Street,
Birmingham.
July 8th, 1922.

U 780

BOROUGH OF KINGSTON-UPON-THAMES.

TECHNICAL INSTITUTE.

Wanted, for the Session

commencing September 26th, an INSTRUCTOR in Machine Drawing and Design for one evening per week.

Salary, at the rate of 10s. per hour for the first two hours and at the rate of 5s. per hour for any period exceeding two hours, together with third class travelling expenses.

Forms of application may be obtained from the undersigned. U 836

H. T. ROBERTS, B.A.,
Principal.

Assistant Works Manager or

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Wanted, Sales Manager for

London Office of large North of England Manufacturers dealing with Government Departments, Railways, Engineers, Merchants, etc. Education and personality of importance, Engineering and Commercial experience might be an advantage. Must be keen, alert, possess initiative and of indomitable perseverance.—Address, U 811, Offices of ENGINEERING.

Secretary-Director Required,

preferably one with knowledge of Engineering, London Company. Investment £2000, secured by Debenture. Salary £520 p.a., Interest 10% plus commission. Present Directors have £16,000 cash invested. Open to Accountant's investigation.—Write, BOX 44, WILSON BELL PUBLICITY LTD., 83, Pall Mall, S.W. 1. U 821

Assistant Inspector of WIRELESS TELEGRAPHY.

There is at present a VACANCY for an ASSISTANT INSPECTOR of Wireless Telegraphy in the Post Office. Candidates should preferably be about 28 years of age; they should either be graduates in Physics or Electrical Engineering who have had a practical training in Electrical Engineering and possess a knowledge of Wireless Telegraph systems and plant, or Naval or Military experts who have had an equivalent training. They will be required to pass a medical examination, and may be called on to serve abroad. The scale of salary attached to the post is £300 to £350 by increments of £15 a year and then to £450 by increments of £20 a year; but the successful candidate will not necessarily be required to start at the minimum if his qualifications are considered to warrant a higher amount. In addition, Bonus is paid on the Civil Service scale which, on the basis of the rates at present in force, would increase a salary of £200 to £348, £350 to £553 and £450 to £689.—Applications, with full particulars of qualifications and experience, and copies of recent testimonials, should be sent to the SECRETARY, GENERAL POST OFFICE, London, E.C. 1, on or before the 31st of July. U 726

ASSISTANT LOCOMOTIVE SUPERINTENDENTS, INDIAN STATE RAILWAYS.

THE SECRETARY OF STATE FOR INDIA will, in 1923, with the advice of a Selection Committee, make

Four Appointments as

ASSISTANT LOCOMOTIVE SUPERINTENDENTS for service on Indian State Railways, if so many suitable candidates present themselves.

Candidates must be British subjects not more than 26 years of age, and must be of good moral character and sound physique. They must have had a good general and technical education, followed by at least three years' training in the Locomotive workshops of a British Railway Company or a locomotive builder of repute, and should have had six months' training in the running sheds and firing. A knowledge of applied mechanics and composition of all materials used in shops is essential, and applicants should be able to design and to calculate the stresses on the parts of the machines. Some drawing office experience is also desirable.

Persons whose practical experience falls short of three years but who have served in His Majesty's Forces during the war will be eligible as candidates; but if selected, will be required before appointment to complete satisfactorily such further period of training as the Secretary of State may prescribe.

Candidates may be required to appear before a Selection Committee at the India Office. They will also be required to pass a medical examination if selected for appointment.

The regulations in respect of the appointments and forms of application for use by candidates can be obtained on application to the SECRETARY, Public Works Department, India Office, Whitehall, London, S.W. 1. Applications for appointment must reach the India Office not later than 31st July, 1922.

India Office,
16th June, 1922. U 637

Wanted, Three Experienced

Mechanical Engineers used to routine work; concentrating on mass production; not engineering but manufactured on high class machinery; in charge of fitters working 3 shifts of 8 hours each. Salary offered £300 per ann. and bonus on production. Applications to be accompanied by copies recent testimonials, BOX F, 323, LEE & NIGHTINGALE, Advt. Offices, Liverpool. U 802

Assistant Marine Engineer

REQUIRED for Lighterage and Tugboat Company in North China. Single. Age about 26. Three years agreement at Mex. $300 per month. Unfurnished quarters. Passage paid.

Practical knowledge of docking and repairing light draught craft and a working knowledge of pneumatic tools desirable.—Write, giving experience and qualifications, to KAOLIN, care DEACONS, Leadenhall Street, E.C. 3. U 618

Engineer.—A Large Engi-

neering Firm in America has a VACANCY for a FIRST CLASS ENGINEER experienced in the design and construction of truck and cubicle switchgear. Only those who are really competent in this particular branch of electrical engineering need apply. State age, experience and salary required and enclose copies of references.—Address, U 795, Offices of ENGINEERING.

Assistant Engineer

REQUIRED by the GOVERNMENT of JAMAICA for Railway Construction. Salary £500 a year and £100 a year field allowance. Free passages. Period of engagement 18 months. Candidates, age not over 35, must be single, well educated and experienced in the location and construction of Railways, in the preparation of quantities, specifications and contracts, also in the construction of bridge work, masonry, etc., and possess a good practical knowledge of the laying out of station yards and erection of Railway Station Buildings.—Apply at once in writing, giving age and brief details of experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/Jamaica 11487. U 791

CHEMICAL ENGINEERS CONFERENCE AT GLASGOW.

(*Continued from page* 51.)

THE MINING OF SULPHUR AND OTHER CHEMICAL INDUSTRIES.

ON the morning of Thursday, the 6th inst., the Local Committee arranged a cinematograph display of films relating to chemical industry. The exhibition was given at the Picture House, Sauchiehall-street. The films shown were the mining of sulphur by the Texas Gulf Sulphur Company, rubber manufacture by the North British Rubber Company, and the manufacture of newsprint at Messrs. Price and Brothers' Mill, Kenogami, Quebec, Canada.

The film showing the mining of sulphur depicted the operations of the Texas Gulf Company at their works at Matagorda County, Texas. This deposit is estimated to contain upwards of 10,000,000 tons of sulphur, and is known as the Big Dome. In the year 1920 this works produced 1,000,000 tons. The dome at the surface is some 2 miles across, or about 3 sq. miles in extent, and rises at its highest point to only about 10 ft. above the surrounding plain. Going down through the ground from the top successive layers of top soil, gumbo, sands and gravel are passed for several hundred feet before the cap-rock or cover is reached, beneath which the sulphur deposit and mixed lime-rock are found. It is from this level that the sulphur is mined. A well is sunk of about 1,000 ft. depth and is provided with a system of pipes through which very hot water is pumped. The temperature of the water before it is forced down the bore is raised sufficiently high to melt the sulphur which flows into a pool at the bottom, where it enters a pipe provided to take it to the surface. The pressure of the column of water added to the pressure applied at the casing head by the pumps raises the sulphur several hundred feet in the pipe, and from there the melted sulphur is brought to the surface as a golden stream, 99·5 per cent. pure. The product is entirely free from arsenic, selenium and tellurium. The sulphur is solidified in thin layers in bins made from heavy tongued and grooved timber. In this way, blocks are built up, layer on layer, until heights of 40 ft. to 60 ft. are reached. When cooled sufficiently, the heavy blocks are broken up by blasting and the lumps loaded into cars by steam shovels. This method of mining sulphur is peculiar to this field, and requires for its successful accomplishment large quantities of water from an unfailing source, large boiler installations to raise the water to the required temperature and an extensive collection of specially-designed pumps. Borings are made continuously so that operations can be continued over another part of the area when any portion gives out.

The treatment of raw rubber from its arrival at the docks, the processes it undergoes in the mill, and the methods of its use in the manufacture of motor and cycle tyres, rubber footwear, hot water bottles and water hose were shown in the North British Rubber Company's film.

Charles Walmsley and Co., Limited, made all the paper machinery shown in the film of the manufacture of newsprint at Kenogami, and their film proved of considerable interest. It depicted the operations of the component parts of an extensive pulping plant, and printing machines with 34 drying cylinders, 5 ft. in diameter, and 10 calenders. The machines are driven by a variable-speed three-cylinder steam engine.

GLASGOW HARBOUR.

Many of the party took advantage of the arrangement made by the Reception Committee with the Clyde Navigation Trustees to visit the Clyde Harbour on Thursday morning, 6th inst. The Clyde Navigation Trustees' boat Comet took the party from the Broomielaw down the river and back. The visitors were greatly interested in the reinforced concrete work in progress at the Kingston Dock, originally built in 1876, but seriously damaged by fire in 1914. The quays on the upper portion of the river which are devoted to the coasting trade, the Princes Dock, built in 1897, and used by Transatlantic liners, and the Queen's Dock, built in 1883, and used to berth boats engaged in Indian and African trade, were visited in turn. The 6-mile run to Dalmuir in which there is a continuous succession of shipbuilding yards, gave the members some idea of what must be the magnitude of Glasgow's normal activity. The Rothesay Dock at Clydebank, with its extensive electrical equipment, the grain stores at Meadowside, and the large sewage purification works at Shieldhall and Dalmuir provided further interest in the enterprise of the Clyde Trustees and the Glasgow Corporation.

After lunch on the 6th inst., the Chemical Engineering Group opened their conference in the Rankine Hall of the Institution of Engineers and Shipbuilders in Scotland.

THE DISTILLATION OF AMMONIACAL LIQUORS.

Britain produces about one-third of the world output of ammonium sulphate derived from the treatment of the gas residues obtained in gas works, coke-oven plants, blast furnaces, and in the carbonisation of shale, and is in no way lagging behind other countries in the development of methods to separate and put upon the market the valuable derivatives of this distillation. The gas residuals are obtained in the ordinary gas works from the hydraulic main liquors which contain from 0·5 per cent. to 1 per cent. of ammonia, the condenser liquors with an ammonia content of something between 2 per cent. and 3·5 per cent. and the scrubber liquors which have very varying strengths, depending on the construction of the washing plant and how its working is supervised. The primary products found in the liquors are ammonium chloride, sulphide, carbonates and cyanide. The strength of the solution is frequently expressed in terms of ounces strength, the figure being the number of ounces of pure sulphuric acid required to neutralise the ammonia contained in 1 gallon of the liquor. A standard of 10-oz. strength is usually employed to express yields for statistical purposes.

The old method of treating the liquor was to neutralise it with acid. This process has many objections as the substance produced contains tarry matter and sulphuretted hydrogen. For some years the ammoniacal liquors have been almost invariably distilled to obtain the ammonia, and the other derivatives have also been extracted. The intermittent working system consists in distilling the free ammonia in externally fired boilers. The addition of alkali to drive off the fixed ammonia was not often used because of the formation of thick deposits of lime salts on the heated boiler plates. The continuous process has now almost completely superseded this method. In the continuous process the stills work on the principle of the old Coffey still. Steam is generally used for the purpose of heating, and is blown through the stills in such a manner as to meet the maximum amount of liquor in its travel. In a simple way the process may be described as the liberation of the free ammonia by the action of heat obtained from the steam and the use of lime, which is the most suitable substance in actual working, to release the fixed ammonia. The gas evolved is passed through sulphuric acid to produce ammonium sulphate. The gas liquor first enters a heater and receives its pre-heat from waste gases, and passes to the top of the column of the still, which is divided into a number of chambers by horizontal division plates. The liquid flows downward from one compartment to another, meeting the steam which is admitted at the foot, and travels upwards. Hoods control the direction of travel of the steam and provide openings to permit it to bubble through the liquor in each section, and drive off the volatile ammonia. A vessel into which milk of lime is passed from an outside tank is used in the expulsion of the fixed ammonia, and the liquor in thin sheets is finally boiled to get rid of the final content of ammonia. This boiling is accomplished by the use of steam coils. The importance of this industry is manifest and the products are essential to many of the arts.

At the afternoon meeting, Mr. W. H. Coleman, F.I.C., presided, when a paper on "The Design and Working of Ammoniacal Liquor Stills," was read by Mr. P. Parrish, A.I.C., who not only dealt with the general problems connected with this work, but described many of the new developments and discussed possible lines of future progress. He stated the yearly production of gas liquor in the United Kingdom as 1,250,000,000 gallons of 8-oz. strength (that is, 1·73 per cent.) ammonia. The lecturer classified the arrangement of continuous process plants into three groups: First, those with the free still above the liming chamber, and with the fixed still apart; second, those with the fixed still at the foot, and the liming chamber above it, but below the free still; and third, those with the free still above the fixed still and the liming chamber separate. He also provided a table showing the dimensions of plants of these three general types. This showed very little standardisation of practice, which is suggestive of the necessity for a considerable amount of experimental work in the problems of ammonia distillation. Descriptions were given of modern plant such as that of Dr. Carpenter, in which the chambers are made of hoods, trays and bubblers, These are made with machined faces to reduce the possibility of the steam taking an unintended path. Another interesting example of modern practice with which he dealt is the still used in the Provan gas works, Glasgow, where the fixed ammonia represents only about 10 per cent. of the total yield. The author stated that the design of stills has been looked at more from the standpoint of construction to facilitate cleaning and for ease of control in working rather than from that of economy in steam consumption. A consideration of the costing of sulphate manufacture showed that the labour involved in the control and operation of stills did not amount to more than 4 per cent., and cleaning only to about 0·2 per cent. of the total cost of manufacture, while the cost of steam used in stills alone, without any consideration of motive power, was 10 per cent. of the total. Efficient use of steam in a liquor still is indicated by the degree of concentration of ammonia in the gas stream. The shells of Lancashire boilers are frequently used as storage tanks for gas liquors, and have proved quite satisfactory. They are elevated so that the contents may be allowed to fall to a constant feed tank with a float valve, which is used to maintain uniform flow to the still. Large cast-iron tanks built up of plates with stiffening ribs are also used, the machine finished joints being coated with red and white lead before erection. Pre-heaters are used for the double purpose of giving the initial heating to the liquor and conserving some of the heat of the waste gases. The efficient use of waste heat in this way provides a very interesting problem to the designer. The detailed design of the various component parts of a complete installation was reviewed, taking examples from modern plant.

Mr. G. Cooper thought that reductions in steam consumption have been effected to such an extent that it is almost impossible to economise further in that item, while the present systems of distillation are in use. He spoke of the effects of changing the size of the serrations in the hoods used in the stills, and suggested that the size is limited by the two considerations of freedom of passage of bubbles and the action of entraining some of the solution. Minimum steam consumption would be obtained if the liquor was introduced to the stills at the steam temperatures. As the steam usage has been reduced to one and a-half times the theoretical amount necessary for the liberation of the ammonia, there seemed, he stated, to be little hope of considerable further reduction.

Dr. Smith suggested that economy may possibly be obtained if the gas works were to send out stronger residuals to the distilling plants. If such a suggestion were put into practice fewer ammonia scrubbers would be required.

Mr. Ramsay Sibbald spoke about a case where a considerable saving was effected by reducing the size of the pipes to the stills. He thought that the alignment of the hoods in the stills was of great importance. If slightly tilted, he anticipated that the steam would pass through more freely at one side and in large bubbles with considerable entrainment of the solution. He described some experiments he had conducted with hoods provided with a series of small holes near the bottom. The holes in use were $\frac{1}{8}$ in. diameter. The fault of the arrangement was that the holes were easily choked. Further experiments with slots cut upwards from the edge and slightly wider than the holes in the previous test, gave results which were much more satisfactory.

Dr. Goodwin referred to the question of the

serrations in the still hoods, and suggested that the question of suitable size could only be settled in relationship to the depth of liquor. He thought that small traces of oil or an oil film might have a great effect upon the efficient contact of the gas and liquor.

The chairman (Mr. Coleman), in referring to the construction of the hoods, described a plant with a revolving shaft to which cup hoods were fitted and in which high efficiency has been obtained.

Mr. Parrish, in replying, said that he thought that only in a few plants was any trouble experienced from entrainment. He is investigating the matter of the maximum strength at which the scrubbing plants in gas works should be worked. Economies might be obtained in both gas works and residual works if the strength of the residuals was increased. He said that he had carried out tests with hoods with holes as referred to by Mr. Sibbald and had carried out experiments with a bubbler with 1,000 such small holes. The alignment of the hood was, he thought, not very important as foundations and supports could be made as strong as necessary. In his opinion the smaller the depth of seal in the hoods, the greater would be the economy from the steam standpoint. As all ammoniacal liquors contain a certain amount of oil, he saw little hope of freedom from any effects that might be caused by oil films.

TAR DISTILLATION.

Tar distillation is a modern development in which considerable progress has been made in the last few years. The process is carried out for the recovery of the many complex organic substances which tar contains. In its composition the tar obtained from gas production in horizontal retorts contains about 60 per cent. to 70 per cent. of pitch and 30 per cent. to 40 per cent. of oils containing aromatic hydrocarbons of the benzene, naphthalene and anthracene series, as well as phenols, pyridines and other organic bodies. The tar produced when gas coal is treated in vertical retorts is of an entirely different character. It contains less benzol than tar from horizontal retorts, very little naphthaline, but quantities of substances of the character of the phenolic materials extractable from wood-tar creosote. A paper on this subject was read by Mr. W. A. Walmsley, who is the superintendent of the Provan Chemical Works of the Glasgow Corporation. He described the new works at Provan, and showed the route taken by the tar products in their series of distillation and other treatments until the refined products were obtained. Tar distilling, he said, could be roughly divided into two parts, the primary or crude distillation and the refining operations. In the first process closed stills are used, and the tar is heated to evaporate from it some of its volatile matter, which is then condensed. The residue in the still is pitch, the condensate is separated into crude naphtha, containing benzine, toluene and carbolic acid; light oils mainly carbolic and cresylic acids with some naphtha; carbolic oil and tar acids; light and heavy creosote oils. These products are refined by further distillation. The stills used at Provan are egg-ended boilers, 9 ft. diameter and 23 ft. 6 in. long, erected with the length running vertical. The furnace is underneath, to the one side, and the firebrick setting prevents the flames coming into contact with the pitch run-off pipe and valve. The gases pass from a pipe at the top of the still to a coil condenser which is surrounded by water in a tank. Stills of other types with accessories to speed up the rate of distillation and to carry out a preliminary dehydration of the tar by the utilisation of the vapours from the tar stills in a system of heat interchanges, are also employed. Other plant in use at Provan consists of double Wilton tar dehydration coils in combination with pot stills. The results of preliminary experiments with the two-coil plant suggests the possibility of continuous tar distillation, and further work is being undertaken to test if it is possible to crack some of the oils produced. A continuous causticizing plant and carbolic extractor designed to make from 10,000 gallons to 20,000 gallons of crude tar acids each week, has been installed at Provan works.

Mr. Nichols asked if it was to be understood that the tars from the vertical and the horizontal retorts were treated separately or together. To this question Mr. Walmsley immediately replied that as they were going to use vertical retorts in all the Glasgow gas works but one, they had not thought it necessary to treat the two tars separately.

Mr. Maclaurin suggested the grading of tars into many classes according to their temperatures of production. Many of the misunderstandings found to exist among people discussing tar problems, could be avoided if such a scale were adopted. If the descriptions, high temperature, semi-high temperature, medium temperature, semi-medium temperature, and low temperature as applied to tar were adopted, and definite temperature ranges assigned to each, the discussion of tar problems would be greatly facilitated. He referred to the production of tar acids by the different types of retorts and at various temperatures. He asked Mr. Walmsley if he thought that under certain temperature conditions some of the phenols are decomposed.

Mr. Parrish called attention to the setting of the stills at Provan and suggested that with the vertical arrangement in use, the time of contact for the gases was very short. In fractional distillation, he considered the important factor was the bubbling action and not the time that the two mediums were in contact.

Mr. Potter asked for figures for the working of Wilton coils. In reference to repairs and maintenance, he said that after 10,000,000 gallons or 11,000,000 gallons of tar had been treated, the second Wilton coil needed repairing, and that later such occurrences were found to take place after the treatment of every 1,500,000 gallons. It pays the user, he said, to remove and replace the bottom layer of coils after 15,000,000 gallons of tar have been treated. There might possibly be some cracking action taking place in the coil still.

Mr. Cooper, referring to possible cracking action of the oils, said that if it was accompanied with the production of carbon the action was a very undesirable feature.

The chairman was interested in heat transmission, and wondered how much heat was available for pre-heating. He was amazed to find what a large amount of available heat went up the chimney.

Mr. Walmsley, in reply, said that at the present moment he had little information available on which to base any conjecture as to what took place in the intricate chemical questions relating to tar distilling, which were referred to by Mr. Maclaurin. In stills with spiral flues, he found that the efficiency was high, but as the gases all took one track, their lives were very short. He promised to provide more information regarding some of the questions when the plant had been tried out and further experiments had been conducted. He found no evidence whatever of free carbon in the substances which remained in the coils when examined under the microscope.

(*To be continued.*)

MASS PRODUCTION AND FOUNDRY PRACTICE.

IN our issue of May 26 last (page 658) we published an article dealing with the general subject of planning for efficient mass production, and we now propose to direct attention to a branch of such planning which in many instances has not received the attention which it deserves. The need of such planning as was described in the article above referred to was undoubtedly one of the contributory causes of the rapid collapse of the post war mass produced motor vehicle in this country. The engineering mass production problem (omitting capital, though that is of primary importance), usually presents itself as follows: To have an article in great demand; a staff to buy the raw and semi-manufactured material; a staff and plant to work it up into the form of the article; and a selling organisation. The now defunct motor boom afforded instances from all over the country of failure in forethought in the design and the capacity of the buying staff in many directions; but in few more markedly than in requirements from foundries. This is not altogether surprising. Most of the firms at all new to the industry viewed the question, apart from sales, as chiefly a matter of assembly; and it is a notable circumstance that few firms of long experience in motor manufacture launched out on the largest scale as mass producers.

Among those who did, however, few possessed their own foundries; and where they did, these foundries were seldom adapted in staff or technique for a large part of the foundry work necessary to the modern pleasure car or commercial vehicle.

It is probably from these causes that, while an immense amount of foundry work was bought outside, the design which would have ensured its rapid and sound production was largely overlooked; or in some cases, apparently, completely forgotten. The trouble was always accentuated where definite strength, equal to that of mild steel or greater, was required, and hence faulty design for casting in aluminium, iron and sometimes brass did not cause the acute troubles that were met when the defects of design arose in steel or malleable iron.

These failures in design may be shortly summarised as follows: Undue intricacy, necessitating several boxes and preventing flat partings; rapid increase or diminution of section; heavy bosses or bulges; sharp corners; great superficial expanse compared with section. The first error precludes rapid machine moulding except after great expense in patterns. The second requires special chilling, or else "rising" in weights equal to, or greater than, that of the whole casting. The third is a special case of this, and can be less expensively dealt with in the same way; it is mentioned chiefly because it is a very favourite error with those whose designing eye is fixed too firmly on the goal of machining and assembly. Castings embodying the fourth defect of design are usually cast otherwise and dressed to shape—needless to say the user pays for the excessive dressing. The last-named defect makes no allowance for the smallest pebble or unevenness of temper or moisture in the sand. It is not to be supposed that all these defects are avoidable errors in every particular case; but clearly, for mass production, most castings should be free from all of them and in those where any are present, care must be taken to minimise their scope and number. During the rush of three years ago, however, the attempt was made to cast many designs where most of the errors described were present in a marked manner, several exemplifying all of them at once in a quite striking degree.

A mass-producing establishment usually depends for much of its raw and semi-finished (*e.g.*, cast) material on firms outside, and therefore includes in its organisation an "outside progress staff." This arrangement has its clear uses; but in practice it has often aggravated the difficulties which it was intended to smooth or prevent. The members of this staff are frequently unqualified to appreciate the technical difficulties due to faulty design; and sometimes when they do, they have not the authority necessary to call for a speedy reconsideration. In the result, after a great deal of friction and delay, nothing is achieved till the heads of the foundries and the motor firms met. The amount of production held up in this way in the past was probably quite equal to that prevented by the moulders' strike. Also a good deal of liquidation sprang from the same source, for several firms having added foundries to their commitments still found various pet designs could not be profitably reproduced.

THE LJUNGSTRÖM TURBINE LOCOMOTIVE.

SINCE the design of the steam locomotive first began to settle down along conventional lines, its chief features have remained practically unaltered. It is true that within the last fifty years, locomotives have increased enormously in size and power, steam pressures have been raised, superheating adopted and compounding has been tried with a certain measure of success, but the motive mechanism still generally remains a simple, non-condensing, open-type reciprocating engine, a prime mover which has long been abandoned for stationary work where economy of operation has been seriously considered. The locomotive engine has retained its position by reason of its simplicity and mechanical reliability, but it is unquestionably very near the limit of its possible development along present lines, taking into account the restrictions of space under

THE LJUNGSTRÖM TURBINE-DRIVEN LOCOMOTIVE.

CONSTRUCTED BY THE AKTIEBOLAGET LJUNGSTRÖMS ANGTURBIN, ENGINEERS, STOCKHOLM.

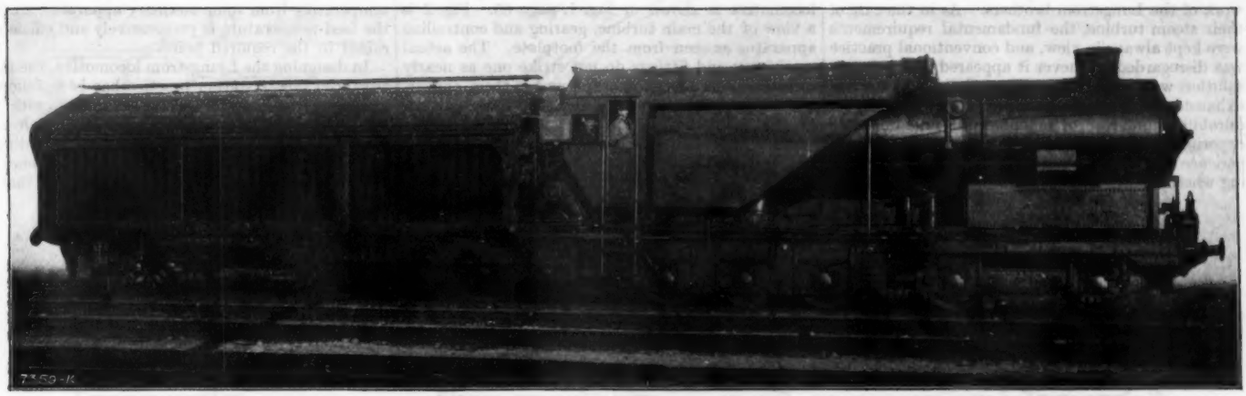


FIG. 1.

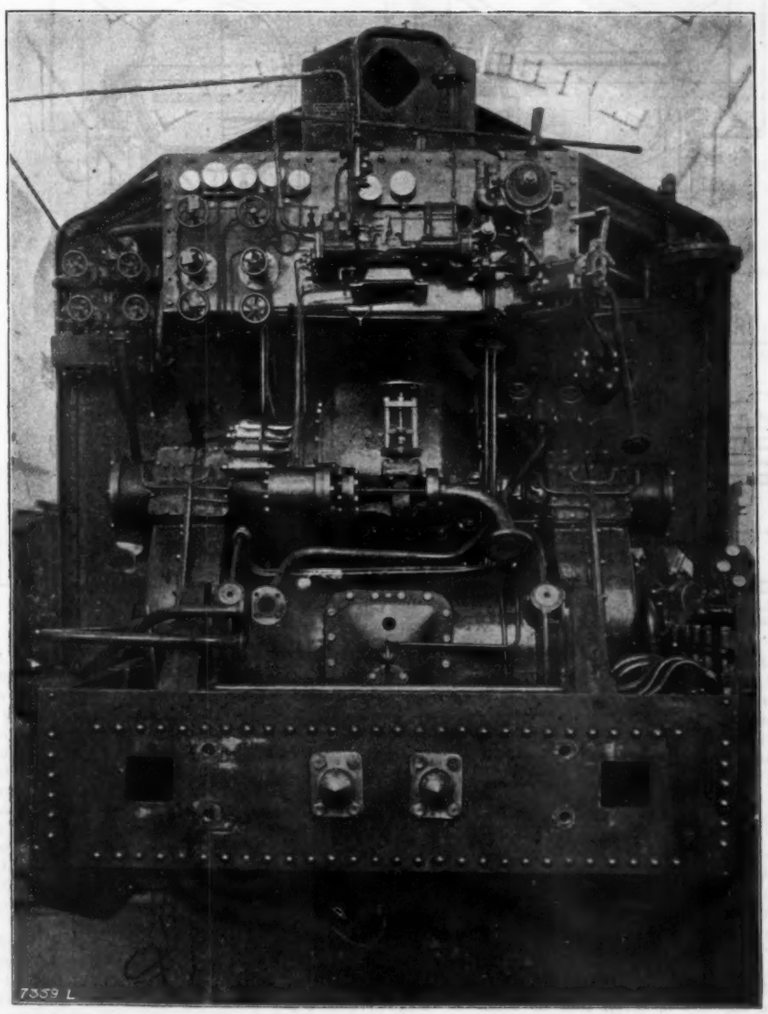


FIG. 2. VIEW FROM FOOTPLATE, LOOKING BACKWARDS.

which the designer labours. Even the practice of compounding has had to be abandoned for the most powerful engines simply because room cannot be found for the larger cylinders required. The continually increasing demand for greater hauling capacity, together with the necessity of securing greater economy in fuel consumption, have combined to emphasise the limitations of the ordinary steam locomotives, and engineers have turned, none too hopefully, to a consideration of the possibilities of electric traction as the ultimate solution of the problem of hauling trains. There is certainly a large field for this form of traction for dense suburban traffic or in countries where water-power is cheap and coal prohibitively dear, but for ordinary long-distance main-line working, the self-contained steam locomotive will undoubtedly hold its own for many a day to come.

A recognition of this fact does not imply that progress in locomotive design must cease because the existing types are not capable of any substantial development. It indicates, rather, that the time has come when any marked advancement must take place along hitherto unexplored lines, and our conventional notions of what a steam locomotive should look like must give way to the fundamental consideration of how best the required conditions can be met in the light of our present engineering knowledge. The problem, briefly stated, is to construct a self-contained, self-propelling steam-power plant, no larger in size than an ordinary main-line locomotive, yet more substantially powerful and more efficient than the latter, and, of course, capable of performing all its duties. The railway engineer can stipulate the conditions which have to be fulfilled, in order to make any radical departure of design worth while, and then the mechanical engineer must take advantage of all modern power-plant experience and scientific knowledge in preparing a design to do the required work. It is, of course, possible in such a case to find that existing practice cannot be substantially improved upon, and under such circumstances there is nothing to be done. But locomotives practice, regarded from the point of view of steam engineering, has lagged so far behind what has been accomplished in power-station work or marine work, that improvement at any rate can be hoped for by reconsidering the fundamentals of the problem with an open mind. When it is remembered that an ordinary locomotive only turns about 6 per cent. of the heat of its coal into useful work, whereas from 20 per cent. to 25 per cent. of the heat of the coal is utilised in modern power plants, it is evident that the locomotive offers great scope for improvement. Doubling the thermal efficiency of a locomotive would reduce the coal consumption and the labour of firing by half, or alternatively would allow vastly more powerful machines to be built with the present practical limitations of firebox area.

Mr. Fredrik Ljungström, the younger of the two brothers, whose work in connection with the steam turbine has been marked by such striking originality and success, set himself, some five or six years ago, to study the steam locomotive with a view to improving its performance. He received occasional assistance from his brother, Mr. Birger Ljungström, the General Manager of the Aktiebolaget Ljungströms Angturbin, in whose factory at Lidingö, outside Stockholm, the work was carried out. Collaborating closely with

the engineers of the Swedish State Railways, whose practical knowledge of service requirements ensured that all necessary conditions should be met, the problem was approached with the same boldness of conception and fertility of resource which might have been expected from the previous work of the Lungström brothers. As in the case of their steam turbine, the fundamental requirements were kept always in view, and conventional practice was disregarded whenever it appeared that a better solution was obtainable. Every detail was studied exhaustively, from the points of view of efficiency, durability and ease of manufacture, and full-scale experiments were carried out whenever actual experience appeared to be the only way of determining whether any departure from accepted practice would justify expectations. It was the object of the designers to repeat the policy which had been followed in respect of their turbine, namely to place upon the market a fully developed machine of which the efficiency was certain and demonstrable, and with regard to which all manufacturing problems had been reduced to a simplicity which made success attainable by any ordinary engineering works.

The result of their labours appeared in March of last year in the form of a completed engine embodying such profound variations from conventional designs, that it really constituted an entirely new departure in locomotive engineering. Acting with the full courage of their convictions, this first machine was not constructed on a small scale or in an experimental manner, but was equal in size to the largest standard main line locomotive used on the Swedish State Railways. It was built for actual service, every detail being completed in what was to be its final form, provided that no unforeseen difficulties in actual work should render modification desirable. After exhaustive tests on a water-brake testing machine, built specially for the purpose, the engineers of the Swedish State Railways were satisfied that the new locomotive could safely be tried under actual traffic conditions, and for many months past it has been housed in the ordinary running sheds of the State Railways and put into service when required, although naturally in view of its novelty, it has been used more for purposes of test and demonstration than for every-day duties.

The external appearance of the Ljungström locomotive is shown in Fig. 1, page 65. Fig. 2 is a view of the main turbine, gearing and controlling apparatus as seen from the footplate. The actual machinery and fittings do not strike one as nearly so intricate as the photograph makes them appear, and it may also be mentioned that more gauges, &c., have been fitted on this first locomotive for the purpose of getting data than would be included in the equipment of an ordinary engine. Figs. 3 to 9 on Plate VIII and Figs. 10 to 12 subjoined show the general arrangement of the whole machine. It is 72 ft. long over the buffers, and weighs, in running order, 126 tons. The motive power is a condensing steam turbine capable of developing 1,800 h.p., which drives the three pairs of coupled wheels by means of double reduction gearing. The turbine, with its gearing, is carried on the front end of what one is tempted to call the tender, but which is really the engine-part of the complete locomotive, as it embodies the whole of the driving mechanism and auxiliary apparatus, as well as the condensing plant. The engine part weighs, in running order, 64 tons, of which 48 tons is carried by the driving wheels. The front part, or boiler part of the locomotive carries the boiler with superheater, and turbine driven induced draught for the air heater and the coal bunker. The coal bunker is in the form of a saddle tank over the firebox end of the boiler, and has a capacity of seven tons of coal. To make this summary of particulars complete, we may add that the tractive effort of the locomotive is 12 tons, and the maximum speed 60 miles per hour.

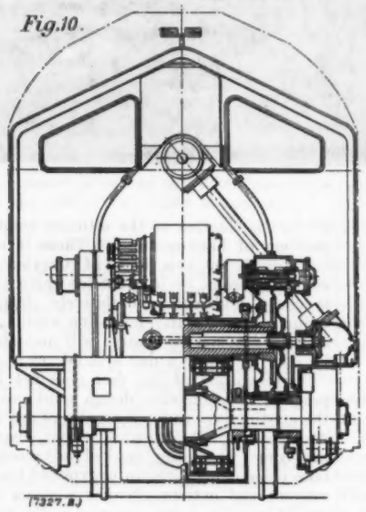
In addition to the features we have mentioned, it should be noted that the design includes forced lubrication to all working parts, which, moreover, are totally enclosed, and a device for blowing the soot from the boiler tubes when running. The boiler is fed with condensed steam at a high temperature, the condensate being driven by a turbine-driven feed-pump through three feed-heaters in series. Each feed-heater takes exhaust steam at a different pressure, and therefore at a different temperature from some auxiliary apparatus, so that the feed temperature is progressively and efficiently raised to the required point.

In designing the Ljungström locomotive, the most advanced power station practice has been followed or adapted to suit the special conditions, with the result that economies have been realised which were utterly unattainable with locomotives of the ordinary type. In actual service the Ljungström locomotive has shown a fuel consumption less than half that of corresponding locomotives of the standard type. Moreover, the adoption of forced lubrication and the total enclosure of moving parts permits of longer-continued runs without stoppages for oiling and cleaning, and helps to reduce the cost of maintenance and the idle time of the machine to figures more or less comparable with what power station engineers are accustomed to. Considered in the light of modern engineering, it must be admitted that the ordinary locomotive, with its working parts freely exposed to dust and grit, and its boiler sometimes fed with water of an undesirable quality, is expected to work under more or less bad conditions, and indeed reliable service can only be secured by an elaborate system of maintenance.

A main line express locomotive in England, does not, as a rule, make a run of more than 150 miles—a matter of a few hours only—without provision being made for inspection. An enclosed stationary engine of equal power, can be operated for weeks or even months without stoppage, and the cost of such refitting or renewals as are necessary during the whole life of the plant is insignificant in comparison with the costs of corresponding work during the lifetime of a locomotive. It is not, of course, to be expected that a locomotive will ever

FRONT. SECTION G.G.

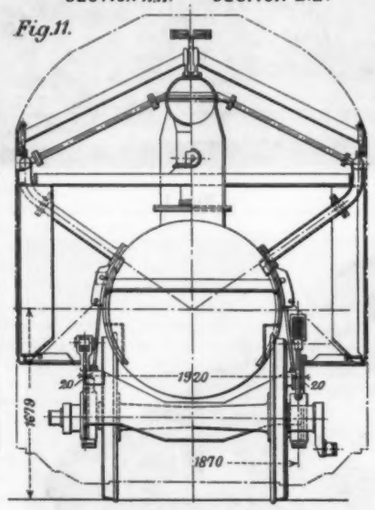
Fig.10.



(7327.B.)

SECTION H.H. SECTION L.L.

Fig.11.



REAR. SECTION M.M.

Fig.12.

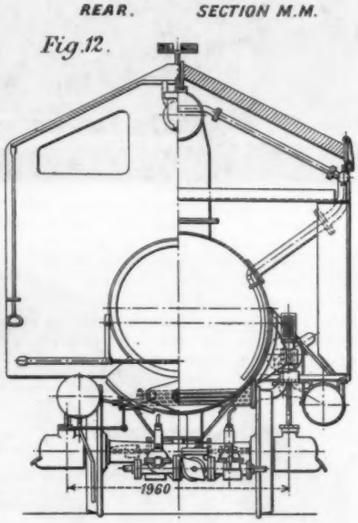
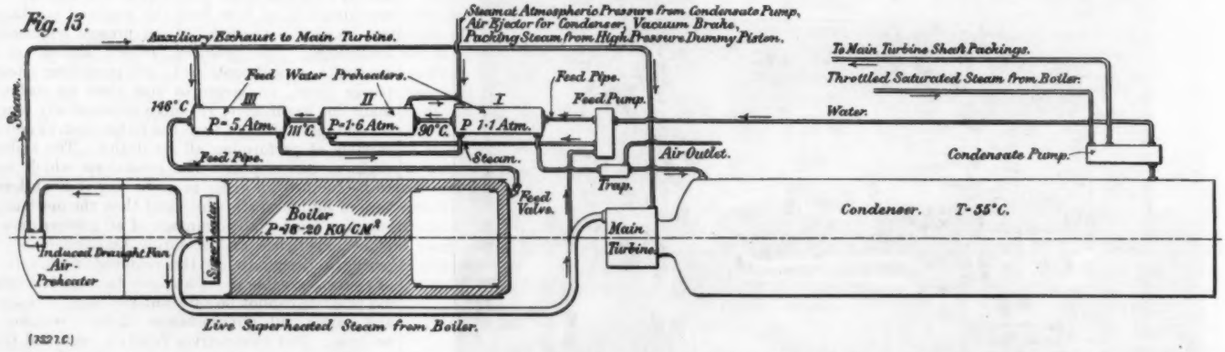
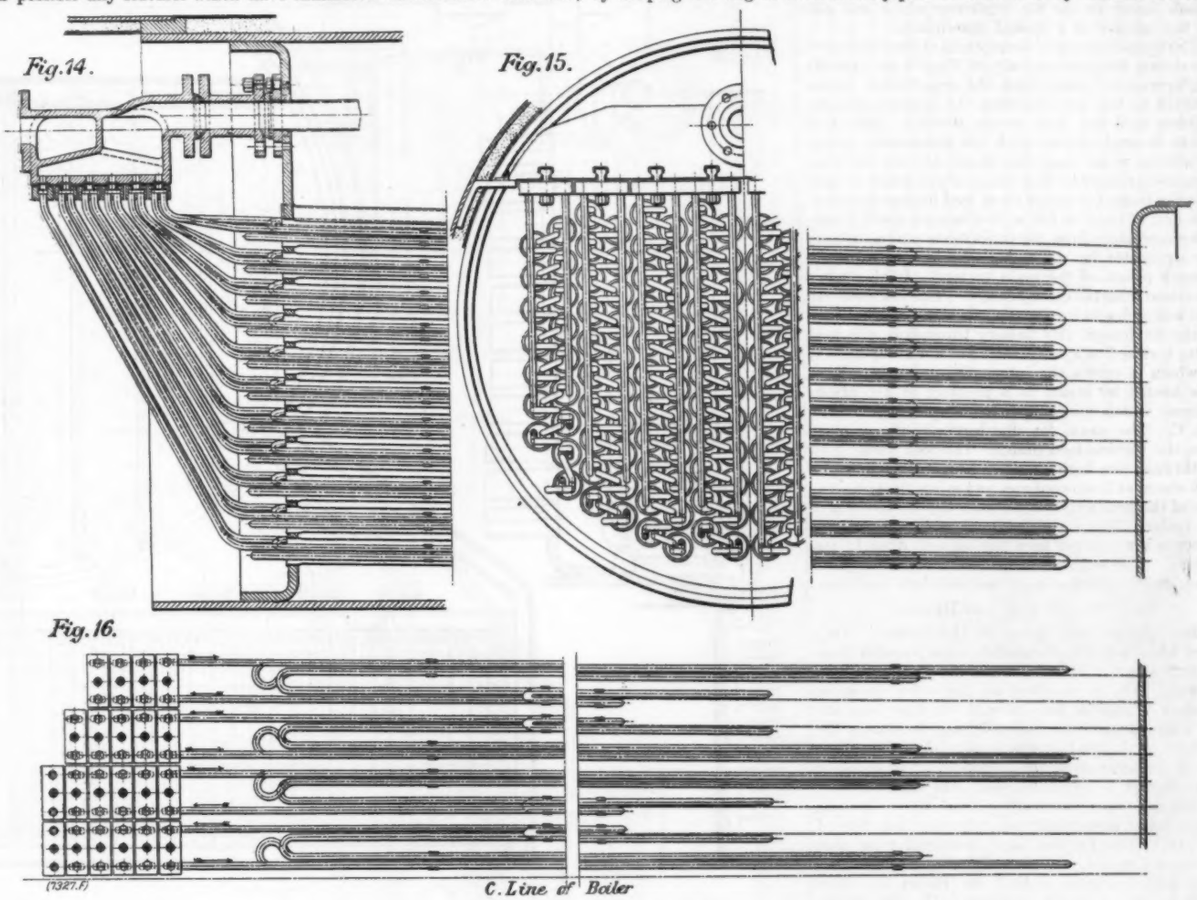


Fig. 13.



(7327.C.)

operate with so little maintenance as a stationary plant, but it is, of course, advantageous to embody as far as possible any features which have eliminated for the purpose of examination and repairs. The reduction of the idle time not only saves direct maintenance costs but, by keeping the engine at have already been mentioned, but the design as a whole is so radical a departure from existing practice, and every part contains so many features of interest



FIGS. 14 TO 16. SUPERHEATER.

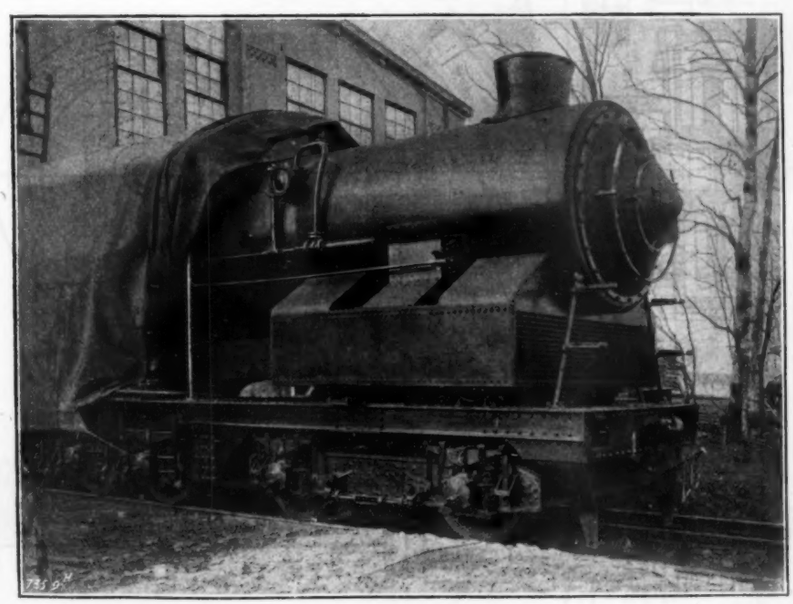


FIG. 17. FRONT OF LOCOMOTIVE SHOWING AIR HEATER.

unnecessary wear and tear in the latter case, with the view of reducing to a minimum the periods during which an engine is withdrawn from service for the purpose of examination and repairs. The reduction of the idle time not only saves direct maintenance costs but, by keeping the engine at useful work, enables the same amount of train miles to be worked by less locomotives.

The general features of the Ljungström locomotive have already been mentioned, but the design as a whole is so radical a departure from existing practice, and every part contains so many features of interest that it is best, first briefly to state the method of operation and then to consider the more important details in turn. Coal descends from the saddle back bunker to two shoots, one on either side of the boiler front, and handy to the furnace door. The hot boiler gases, after passing the superheater tubes, circulate round the tubes of an air heater before going up through the funnel. The air for combustion enters by adjustable louvres below the smoke-box and passes through the heater tubes, and thence is led by a sheet-iron duct to the ash-pan. This heater raises the temperature of the incoming air to about 150 deg. C. at the expense of the waste heat of the flue gases, and promotes much more efficient combustion in the firebox. The flue gases are also so much reduced in volume and temperature, that they can be effectively handled by a small turbine-driven induced draught fan, situated at the base of the funnel. This fan provides a controllable draught for the furnace. There is, of course, no steam blast in the funnel, as the whole of the steam from both main and auxiliary turbines is condensed and returned as feed-water to the boiler. The steam from the latter, after leaving the superheater passes back through an external pipe to the main turbine which is mounted crosswise on the front of the "engine-part" of the locomotive. The turbine spindle is extended at both ends and carries double helical pinions which normally gear with wheels on the end of the second motion shaft. A central pinion on this shaft drives the third motion shaft, at the ends of which are the cranks to which the coupling rods are attached.

Reversing the locomotive is effected by disengaging the last gear drive and inserting an idle pinion at this point. The operation is carried out

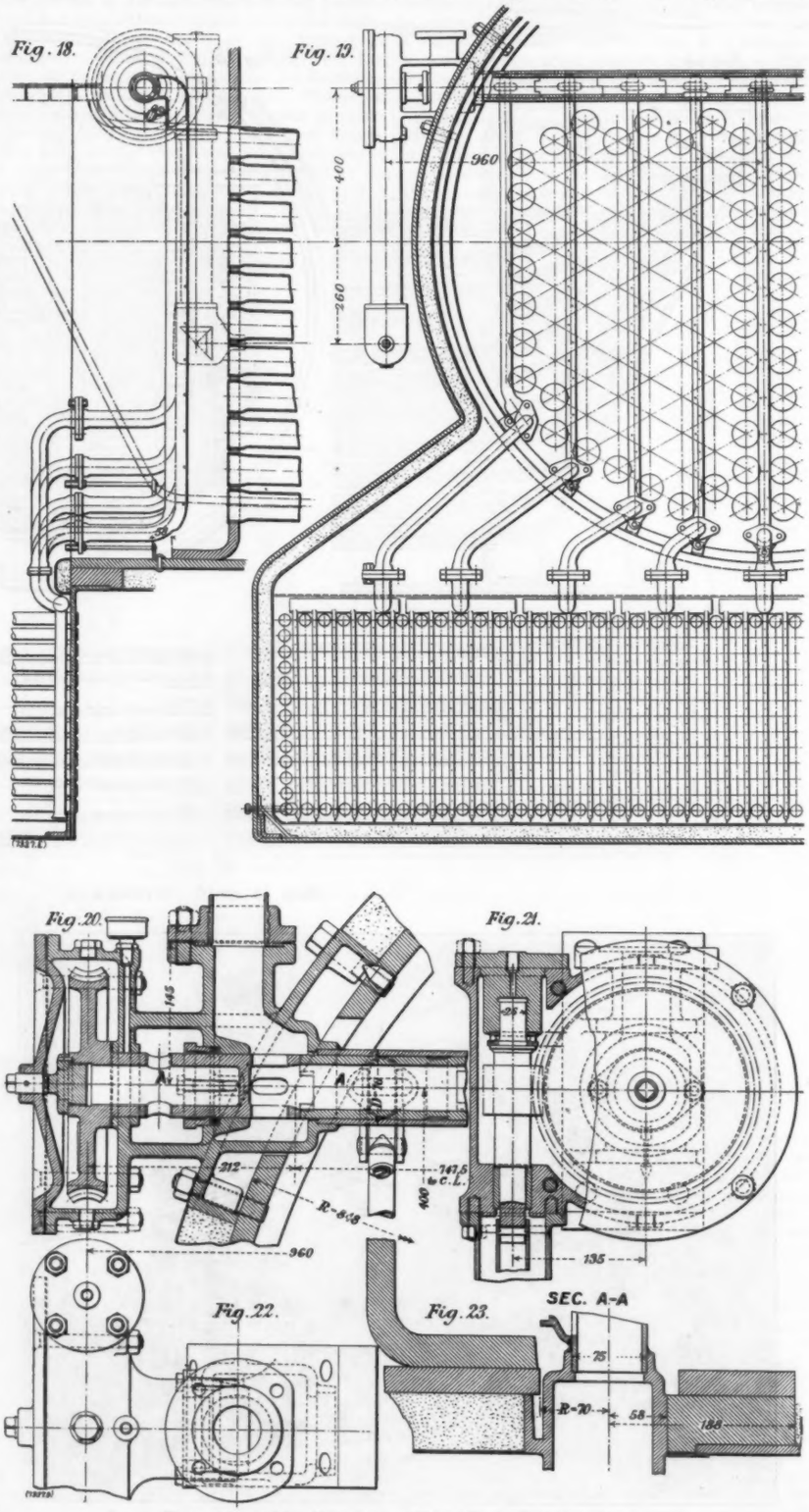
by means of a hydraulic mechanism actuated by the pressure of the lubricating oil, as will be fully described later. The exhaust from the main turbine passes direct to the air condenser which will also be the subject of a special description.

The steam and water connections of the locomotive are shown diagrammatically in Fig. 13, on page 66. High-pressure steam from the superheater passes directly to the main turbine, the induced draught turbine and the feed pump turbine. Saturated steam is employed to work the condensate pump. It will be noted that this pump delivers the condensate to the boiler feed pump, which forces it back into the boiler by way of three feed heaters in series. The first of these is fed with steam at about atmospheric pressure from the condensate pump turbine, the air ejector for the vacuum brake and from the dummy piston of the main turbine. It also takes the steam from the other heaters. This low-pressure feed heater drains into a trap, the water going thence to the condenser. By passing through it, the feed water is raised to a temperature of about 90 deg. C., at which it enters the intermediate heater. Here it is heated by steam at a pressure of 1·6 atmospheres, which raises it to a temperature of 111 deg. C. The steam for this heater is the exhaust from the turbine feed pump. The feed water goes on through the high pressure heater, which works with steam at 5 atmospheres and raises the temperature of the feed water to 146 deg. C. before it enters the boiler. The steam used in this high-pressure heater is the exhaust from the induced draught fan turbine. The exhaust from the condensate pump serves to supply the main turbine shaft packings.

The Boiler and Air Heater.

The external appearance of the boiler is very much like that of the ordinary large Swedish locomotive except of course for the saddle-shaped coal bunker. This is moulded at the sides so as to interfere as little as possible with the view from the cab windows, and the tapered form facilitates the delivery of the coal to the bunker doors at either side of the fire-box on the footplate. The capacity of the bunker is 7 tons of coal. The disposition of the bunker doors relatively to that of the fire-box makes firing particularly easy from either side of the cab. The fire-box is of standard type and dimensions, with a grate area of 2·6 sq. m. (28 sq. ft.) and a heating surface of 10 sq. m. (108 sq. ft.). It is shown in Figs. 4 and 8, on Plate VIII. The boiler, which works at a pressure of 300 lb. per square inch, contains 160 tubes, giving a tube surface of 105 sq. m. (1,130 sq. ft.). These tubes are only 3 m. long, or about two-thirds the standard length of tubes for such a boiler. It has long been recognised that the front ends of the tubes in a locomotive boiler do very little towards raising steam, as the rate of heat transmission falls off very rapidly from the fire-box end. Messrs. Ljungström, therefore, decided to cut off the inefficient front of the tubes altogether, and to return as much as possible of the remaining heat of the gases to the furnace by using it to heat the air required for combustion. This is, we believe, the first time that air pre-heating has been adopted on a locomotive, although the benefits of the practice have been recognised for many years in connection with stationary boilers. The gases leave the ends of the boiler tubes at a temperature of about 320 deg. C., which is high enough above the temperature of the steam to permit the superheater to work under advantageous conditions. This temperature is reduced to about 150 deg. C. by the action of the air heater, which raises the temperature of the incoming air to about 150 deg. C.

The air heater is shown in section in Figs. 4 and 7, on Plate VIII, and its external appearance is particularly clearly seen in Fig. 1[7], page 67. It consists of a nest of tubes running in a fore and aft direction, situated directly beneath the smoke-box. The latter is divided by a vertical cross diaphragm into two parts. The hot gases coming from the boiler tubes enter the rear part of the smoke-box and then have to descend into the air heater. They pass along the outside of the air heater tubes and then rise into the front end of the smoke-box, whence they are delivered into the chimney by the turbine-driven fan shown in Fig. 4. The heater tubes are of brass, 1·5 mm. thick, 33 mm. external diameter, and 2724 mm. long. They number 650 altogether, and give a heating surface of 166 sq. m. (1,787 sq. ft.) The lower side of the front part of the heater casing forms a hopper in which soot and flue dust can collect, to be dumped at will. The rear ends of the air heater tubes open into a duct of sheet metal which leads to the closed ash pit as seen in Fig. 4. Before the front ends of the heater tubes, are a number of shutters which can be opened or closed at will. These can be seen on the left-hand side of Fig. 7, Plate VIII. Their purpose is to regulate the air supply to the ash pit. The handle in the cab, by which they are operated is interlocked with the mechanism for opening the fire-box doors. It is therefore impossible for the firemen to open the



FIGS. 18 TO 23. DETAILS OF TUBE BLOWING APPARATUS.

LJUNGSTRÖM TURBINE-DRIVEN LOCOMOTIVE: DETAILS OF INDUCED DRAUGHT FAN.

CONSTRUCTED BY THE AKTIEBOLAGET LJUNGSTRÖMS ANGTURBIN, ENGINEERS, STOCKHOLM.

Fig. 24.

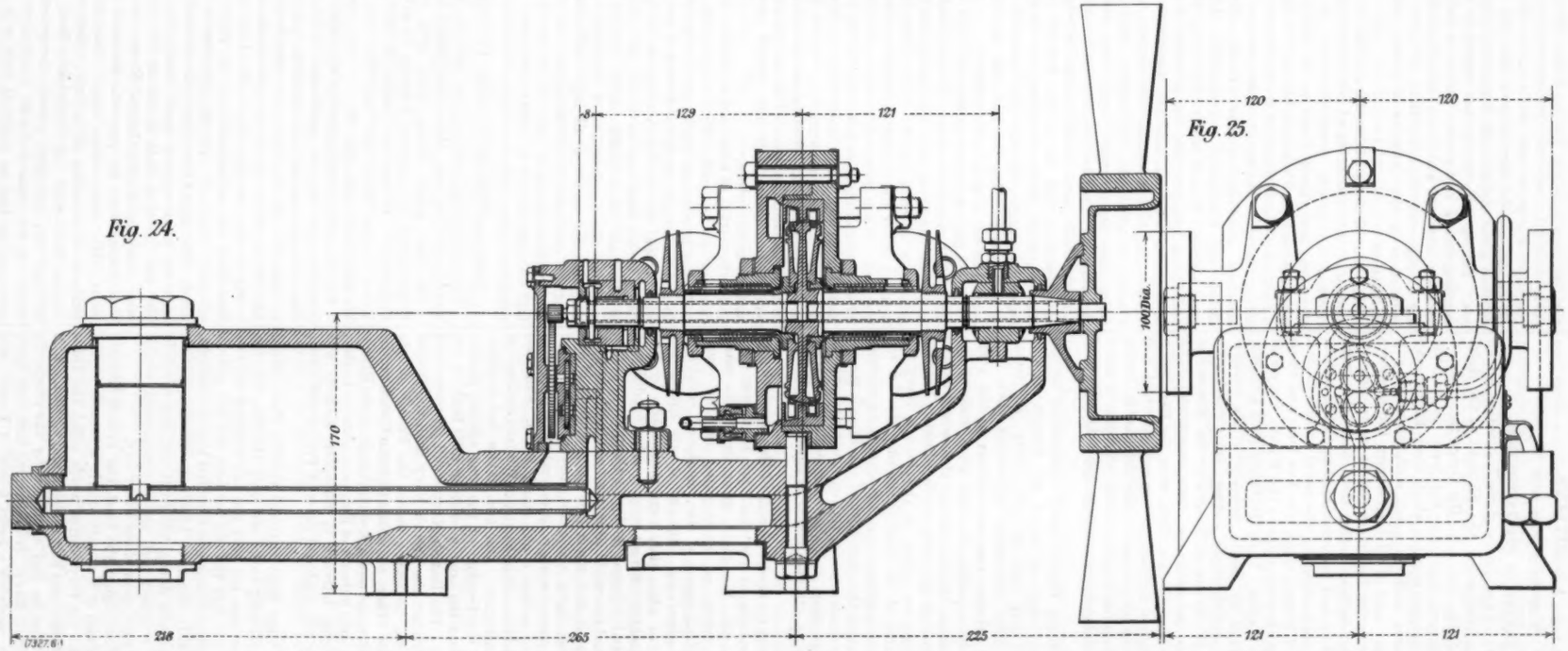


Fig. 25.

fire-box doors unless the shutters are closed, a simple precaution which prevents flame being blown out of the fire-hole by the draught which the speed of the engine would otherwise cause. In connection with the question of using air heaters upon locomotives generally, it may be pointed out the temperature of saturated steam at 250 lb. per square inch is 205 deg. C., so that even were the boiler capable of 100 per cent. efficiency, the flue gases could not leave below this temperature, while any superheat required still further raises the minimum exit temperatures of the gases. The gases do, in fact, leave the tubes of an ordinary locomotive at a temperature of 300 deg. to 350 deg. C., while with the Ljungström air heater, their final temperature is reduced to about 150 deg. C., the heat abstracted from them being given up to the incoming air. Not only does the heated air promote better combustion and more efficient furnace conditions, but the effect of cooling the flue gases is to reduce them in temperature and volume to a condition in which they can be effectively handled by a small high-speed fan.

THE SUPERHEATER AND TUBE BLOWER.

The superheater, as will be gathered from Figs. 14 to 16, on page 67, follows ordinary locomotive practice. Each element is heated by the gases from two boiler tubes, the superheater tube making four passes in one tube and then four passes in an adjacent tube before returning again to the header. As will be seen from the drawing these passes are consecutively shorter and shorter as the steam becomes superheated. The heating surface of the superheater is 80 sq. metres (861 sq. ft.)

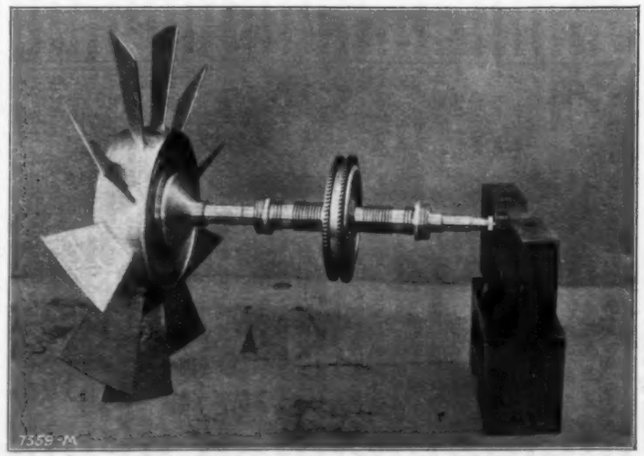


FIG. 26. ROTOR OF INDUCED DRAUGHT FAN.

The apparatus provided for sooting the boiler tubes is illustrated in Figs. 18 to 23, on page 68, the two earlier figures showing the general arrangement and Figs. 20 to 23, giving the mechanical details. In the smoke-box there is fitted a cast-iron steam pipe running horizontally across the front tube plate just above the upper row of tubes. From this pipe descend smaller vertical pipes opposite the spaces between alternate pairs of vertical rows of tubes. When they reach the lower ends of their respective tube rows, the pipes are bent outwards and terminate each in a separate short horizontal length lying along the top of the air heater tubes. Each vertical pipe has small holes drilled in it opposite the ends of the boiler tubes which it passes, and the lower horizontal end is also drilled. When the engine driver wishes to "soot" his tubes he can admit steam to the vertical pipes one by one in turn. The steam escapes in jets from the drilled holes and blows the soot out of the adjacent rows of boiler tubes and also off the air heater tubes beneath.

The method of operation is as follows: Inside the horizontal steam pipe are a number of loosely fitting cast-iron cylindrical valves, each clutched to the next before it and so arranged that by the rotation of the series of valves one vertical pipe at a time is put in connection with the steam supply. The driver rotates the valves by means of the worm and wheel gear shown in Figs. 20 and 21, the worm being turned from the cab by a

wheel which operates the shafts and bevel gearing. The tubes are blown in sections consisting of two vertical rows at a time. This, of course, obviates the stoppage of the draught which would result from attempting to blow all the tubes simultaneously.

The Induced Draught Fan.

Ever since the days of George Stephenson it has been the practice to provide the draught for locomotives by turning the exhaust steam up the chimney. This involves waste of heat and of water, but as the ordinary locomotive has no provision for condensing its steam, the practice has endured. The Ljungström turbine locomotive, however, works condensing, and thus there is no exhaust steam available to create a chimney draught. This is therefore provided by a small turbine-driven induced draught fan, mounted on the top of the smoke-box front. Its position can be seen in Fig. 4 Plate VIII. The use of such a fan is rendered possible, or at any rate greatly facilitated by the fact that the exhaust gases which it has to handle have been reduced greatly in temperature and volume by passing round the tubes of the air heater. The funnel casting inside the smoke-box terminates in an annulus with its axis horizontal, and the fan blading works opposite the annulus and draws the gases from the smoke-box, and drives them into the funnel by a sort of impeller action. The gases pass axially through the fan blading, and the diverging interior walls of the annulus permit their velocity to be reduced and their direction to be changed in as efficient manner as possible. The end of the casting containing the turbine projects from the front of the smoke-box. The projecting portion is an oil reservoir, and it is purposely exposed in order to take advantage of the cooling action of the air when the locomotive is running.

A section through the induced draught fan is given in Fig. 24, page 69, and an end view in Fig. 25. The shaft with the turbine wheel and impeller in position are shown separately in Fig. 26. The impeller is cut from a solid disc of steel, blades and all, as the stresses under which it works are very severe. As will be seen in Fig. 24 the impeller boss is counterbored from both sides, so that the comparatively heavy rim which carries the blades is flexibly connected to the centre. This has been done to enable the rim and blading to rotate about its own centre of gravity, and thus to run without vibration at the very high speeds at which the fan operates. The fan will run at 10,000 r.p.m. and the turbine driving it will develop 40 h.p. at that speed. The turbine itself consists of a single velocity compounded impulse wheel with two running rows of blades. It has a mean diameter of 120 mm. (4·72 in.). The blades are welded up into complete rings, and these blade rings are then clamped against the central disc of the turbine wheel by end plates secured by nuts on the shaft. The turbine shaft is not flexible, but it is hollow, and carries a flexible central spindle to which the fan is attached, the construction being clearly shown in Fig. 24. Steam leakage along the shaft is prevented by the usual labyrinth glands, one at each side of the wheel. The turbine works with full boiler pressure, but exhausts against a back pressure of 75 lb. per square inch, the exhaust steam from it being either used in the high-pressure feed heater, or passing to the main turbine where it is expanded usefully down to condenser pressure.

Outside the turbine glands will be seen pairs of comparatively large discs mounted on the turbine shaft. These are coolers to prevent heat travelling from the turbine casing to the bearings, their high speed of rotation and large surface causing them to act as effective coolers. The bearings are of the plain rigid type, the one furthest from the fan having a single thrust collar to locate the shaft axially. They are fitted with forced lubrication, the oil being supplied under the pressure of a gear pump driven by reduction gearing from one end of the central spindle of the turbine shaft. The comparatively large size of the oil reservoir is well shown in the drawings, and its function as an oil cooler has already been referred to. A removable strainer is provided to keep dirt out of the lubricating system, and large plugs are fitted to enable the oil tank and passages to be easily cleaned out.

(To be continued.)

THE INSTITUTION OF NAVAL ARCHITECTS.

(Concluded from page 37.)

Dinner of the Institution.

Speaking at the dinner of the Institution, which was held on Wednesday, the 5th inst., at the Hotel Continental, the chairman, His Grace the Duke of Northumberland, said that the toast he had the honour to propose was one which every Englishman would receive with as much enthusiasm as any Frenchman. And of all Englishmen, the members of the Institution had most reason to welcome it, for nobody realised better than they the great benefits which had been conferred upon the science of naval construction by the naval architects and engineers of France, those who had built and those who had worked the ships of the French Navy and Mercantile Marine. Here His Grace paid a tribute to the work of Mr. Bertin, president of the Association Technique Maritime, adding that it could truly be said that the two societies were the pioneers of the *entente* between our two countries. Long before the historic date, 1904, when the foundation of that alliance between the two nations which had done so much for civilisation was laid, the two bodies were working out together those principles of naval warfare which were successfully applied in the great war.

In honouring French naval construction we did not forget what we owed to French sailors. Had there ever been in past history, His Grace asked, a more remarkable agreement than that concluded between our two nations in the years immediately preceding the war, when realising the German danger ahead, a danger that would require the presence of the bulk of the British Navy in home waters, we ceded to the French Navy the naval control of the Mediterranean. He did not think there could have been a more striking example of our trust in the good faith of the French people, nor of our confidence in the efficiency and skill of their sailors, than such an understanding, contrary as it was to all the former traditions of British policy.

There was no need to speak of the association of our two navies in the war, for that was well known to all. We could never forget the many occasions when we participated in the most difficult of all forms of war, combined naval and military operations, difficult at all times, but especially so when they were undertaken by two nations speaking different languages, having different methods and different modes of thought.

Never had the world situation been more complex than it was to-day, never had the conditions of the future been more uncertain, never had Europe presented more obscure political and social problems. No nation to-day could stand alone. Our two peoples had formed the barrier of Western civilisation against barbarism. Our two navies had together preserved the freedom of the seas against piracy. We still had the same mission to fulfil both on sea and shore. The British Navy could no more fulfil its part without the French Navy than the British people could be secure unless the French people were secure. There was once a German Watch on the Rhine; there was now a French Watch on the Rhine. It was the chief bulwark of European security to-day, and the other bulwark of European security was formed by the combined fleets of France and Great Britain.

It was their hope that the visit to Paris would result in drawing closer not only the ties between the two nations, not only the ties between the two societies, not only the ties between the two navies, but also those bonds which united the two nations, bonds already cemented by all the blood and tears shed in common during the great war, and which in face of a common peril and common need would, the Duke said, grow closer every day.

In acknowledging the toast, the French Minister of Marine said it was particularly agreeable to him to reply to the very cordial words which the Duke of Northumberland had uttered, and to thank him for the wishes he had expressed for the prosperity of the French Navy. In welcoming him, they knew they were receiving a great friend of France, and the sentiments of friendship which they entertained for Great Britain were similar to those which His Grace had for France. As he did, so they also believed that the Franco-British Entente, by guaranteeing the respect of treaties, was the strongest guarantee for peace and the security of nations. As he did, so did they believe that the Entente between Great Britain and France was an enduring one. During the war, it was sealed by common sacrifice, sorrow and glory. To-day it rested upon common interests, and these, notwithstanding passing divergencies, were identical for both because they were in the interests of peace, justice and civilisation.

Here the Minister of Marine recalled briefly the history of the Institution of Naval Architects, and referred to former presidents and to present members, and among them to Sir Philip Watts, who designed the Dreadnought, and Sir Eustace T. d'Eyncourt, the architect of the Hood among other ships. Between the naval constructors of the two countries there had always existed relations of esteem and friendship, and emulation fruitful in good results. Froude had studied ship resistance, and Bertin had gone into the problems of stability of warships; France built the water tube boilers, whilst England invented the steam turbines; France invented the submersible and England built the Dreadnought and then the Super-Dreadnought; England launched the Mauretania and Lusitania (the name of which would be remembered in connection with one of the greatest crimes in history), while France launched the Paris. Thus from one country to the other progress followed progress, and during the war this emulation was carried as far as it possibly could be.

During the war, Great Britain built 770 warships, and 1,600 merchant ships. During that period, in France, the naval yards were compelled to devote absolutely all their activity to the manufacture of artillery and of the enormous quantity of munitions required. When, however, owing to the prodigious effort they had made in this direction the crisis was met, the French yards undertook the building of despatch vessels, gun-boats and vedette boats for co-operating with the allied navies in the countering of the submarine menace. This patient and genial co-operation during war time would continue as actively in the future.

The limitation of warship displacement was a new problem to be met. The compromise solution embodied in warships would now be more difficult to arrive at, since the limits were now narrower, as was pointed out at the meeting on the preceding day. In the same way as in the past, the building of merchant ships would benefit by the progress made in the construction of warships. The sea had been the cradle of all high civilisation in the past; it continued its civilising mission, and naval construction remained one of the most powerful and efficient factors in human progress, by consolidating peace and developing commerce.

Contrary-Turning Co-axial Propellers.

The concluding meeting was held on Thursday morning, the 6th inst., also at the Collége de France.

The first paper taken dealt with "Further Experiments on Contrary-Turning Co-axial Screw Propellers." It was by General G. Rota, of the Royal Italian Navy, who read it to the meeting. We reproduce it on page 90.

The discussion was opened by Mr. Luke, who said it was a matter of great gratification to his company that the experimental data which he was privileged to present to the Institution on their behalf should have been found to be of assistance to General Rota. Going at once into the subject, Mr. Luke remarked, that there was no indication in the paper as to the efficiency obtained with the single-screw arrangement. That might have been radically bad, in which case an improvement could hardly be avoided. He was gratified that so far as his experiments were comparable with General Rota's work to find their results were, for practical purposes, in agreement. His results were simply obtained for the purpose of rounding-off a long series of experiments, but work at Clydebank being usually of large size and high power, the co-axial screw work was not connected with practical work in his case, and he had no practical data with which to compare his company's model work in any way.

He would study General Rota's experiments in detail and with much interest. Speaking generally, he still remained sceptical in the matter of high hull efficiency meaning the same thing as high overall efficiency. If that were so, one could obtain similarly high results in ordinary twin-screw work, by arranging bossing more nearly in the horizontal direction than was customary—though the drawback of increased resistance would be encountered. It should be remembered that the factor in hull efficiency usually called the "wake gain" was only there to restore an algebraical balance. Another term was divided by this factor for convenience. Had this stray term not been combined with that which measured thrust deduction loss, one would not have been attracted by hopes raised by the, so-called, hull efficiency, when it happened to possess a high value. It was a phantom, and one could not too often utter a warning against being deceived in this regard. He knew quite well, of course, that General Rota was not deceived in this way. The author hoped for an increase in propulsive efficiency; it seemed to him (the speaker) that such an improvement as he might be able to effect would be in the design of good propellers, especially in their special relationship with regard to each other, and not on account of there being a high hull efficiency value. General Rota's experiments, in fact, showed what it was possible to achieve by assiduously following up a problem and exhausting the possibilities of the case. He (the speaker) sincerely trusted General Rota would succeed in realising the high hopes he entertained, and that he would be successful in adapting the arrangement to higher powers.

Mr. Sydney Barnaby announced that he would contribute to the written discussion, but wished to express the gratitude of the Institution to the author for having submitted a second paper on the subject. He (Mr. Barnaby) was shown by General Rota, in Rome, the results he had obtained, and proposed to the council that a paper, the present one, on these results should be given, feeling confident that it would be one full of interest.

Sir Archibald Denny said the subject was a very difficult one; he had made many trials and had met with many failures in attempts made to improve screw efficiency. He had tried, among others, guide-blade propellers, which proved very promising, working on the same lines as Wagner. Much money was spent on the experiments, instructions given were followed, but there were no practical results at all. He was not so hopeful as Mr. Luke in the matter. If, for instance, on a small launch results were obtained which appeared better, it might be assumed that the original propeller was not a good one. He still felt that the straight screw was a better piece of apparatus, and when an efficiency as high as 74 per cent. was obtained one could be satisfied with that. He was, however, carrying out further experiments on the subject, the results of which would be published.

On the motion of the chairman, General Rota, a distinguished representative of the Italian Navy, was accorded the thanks of the meeting for his valuable contribution to the Institution's proceedings.

Proportions and Block-Coefficients of Merchant Steamers.

The last paper on the list was one having the above title, by Mr. W. J. Lovett, who read it in abstract. We reproduce it on page 94. Mr. Lovett called attention to the number of vessels having speeds between 15 knots and 23 knots in 1914–15, namely 878, as against 689 only in 1921–22; also to water channel depths referred to in his paper, a point which was dealt with also in the discussions on the two preceding days.

The discussion on Mr. Lovett's paper was opened by Mr. Doyère, who asked to put before the meeting the results of experiments made in the French tank at Grenelle on the resistance of merchant ships. The usual experiments related to warships, but there had been many opportunities for making trials with merchant ship models and comparing these short, full-shaped and slower vessels with naval ships, the speed of which required much greater lengths and much smaller block or cylindrical coefficients, $\frac{W}{L\,l\,p}$ or $\frac{W}{B^2 L}$. Every member was familiar with the usual shape of the curve which gave the total resistance of a ship in function of her speed, and every member was aware of what was called the critical speed, *i.e.*, the speed at which the resistance, which had slowly increased up to that point, suddenly grew so quickly that a large expenditure of power became necessary to meet that resistance and to gain a knot or half a knot more.

For warships the cylindrical coefficient was, on an average, in the neighbourhood of 0·60 (between 0·55 and 0·65), and the critical speed, measured in knots, might be assumed:

$$V c = 0{\cdot}26 \text{ or } 0{\cdot}27\ \phi\ \sqrt{L}$$

Where L was the length of the ship in metres and ϕ a coefficient given by

$$\phi = \frac{L}{\sqrt[3]{W}}$$

where W was the volume of the hull in cubic metres. (With British units, feet and cubic feet, ϕ had the same value, and $V c = 0{\cdot}14$ or $0{\cdot}15\ \phi\ \sqrt{L}$).

For merchant ships, whose cylindrical coefficient $\frac{W}{B^2 L}$ rose up to 0·75 or 0·80, Vc was smaller and given by

$$V c = 0{\cdot}22 \text{ or } 0{\cdot}23\ \phi\ \sqrt{L}, \text{ in French units, and}$$

$$V c = 0{\cdot}12 \text{ or } 0{\cdot}13\ \phi\ \sqrt{L}, \text{ in British units,}$$

and even with an exceptionally full-shaped cargo boat, having $\frac{W}{B^2 L} = 0{\cdot}89$, he had found

$$V c = 0{\cdot}18 \text{ or } 0{\cdot}19\ \phi\ \sqrt{L}, \text{ in French Units, and}$$

$$V c = 0{\cdot}10 \text{ or } 0{\cdot}11\ \phi\ \sqrt{L}, \text{ in British units.}$$

This showed the importance which the cylindrical coefficient had for that class of slow ships.

For fast vessels, the most important factor of resistance was the length coefficient ϕ or some equivalent. ϕ as above expressed $\frac{L}{\sqrt[3]{W}}$ represented the length of a ship's model having a volume equal to one unit (either cubic metre or cubic foot), when L was equal to ϕ m. or ϕ ft.

The value of ϕ for warships varied from about 5·5 (old battleships) to 9 (modern torpedo boats or destroyers), and though other factors had an influence on the value of resistance, they were secondary compared with the length coefficient.

For cargo boats and slow merchant steamers, the length coefficient was in the vicinity of 5 or 5·5 (rising to 7 or 7·5 for fast passenger steamers which may be likened to cruisers). The value of ϕ was of relatively small consequence, and the cylindrical coefficient was the most important of all. The displacement of the ship had, of course, to be considered. But if each model were supposed to represent a ship of 10,000 tons displacement, and if there were deduced from the actual results of the model experiments the figures corresponding to 10,000 tons displacement, it was found that the mean value of the resistance for slow ships at a speed of 11 knots was about:

1·9 k.	per ton of displacement when	$\frac{W}{B^2 L}$	=	0·55
2·0	,,	,,	,,	= 0·60
2·2	,,	,,	,,	= 0·70
2·4	,,	,,	,,	= 0·80

These figures corresponded to a ship whose ratios between the mean depth and the beam $\frac{p}{l}$ was about $\frac{1}{3}$ or 0·33; when that ratio had another value, a correction had to be made. There were, of course, other factors of resistance, such as shape of the lines, length of the middle body and so on. But the value of the cylindrical coefficient was the prominent factor of comparison.

Mr. Doyère added that a ship model might be considered as representing, at different scales, an infinite number of ships of different displacements, and the direct frictional and total resistance of those ships at different speeds might be calculated. If one chose for all those ships the same speed, say 15 knots, and drew a curve, the abscissæ of which gave the displacements of the ships and the ordinates their total resistance, that curve was quite different from a straight line, a parabola or any other regular algebraic curve. Its slope varied greatly, and a fact of very great importance was as follows: In certain parts of the curve the tangents were nearly horizontal; this meant that within the limits of corresponding displacements, the resistance of those different ships was practically the same. For example, a ship similar to the battleship Danton required the same power at 20 knots for displacements varying from 25,000 tons to 30,000 tons. For other speeds, a similar occurrence took place for other limits of displacement. It might even happen that the slope of the curve was negative in certain parts, which meant that the resistance of a ship at a certain speed V might be smaller than that of a smaller similar ship at the same speed.

Therefore at a given speed for ships of the same lines there were favourable and unfavourable displacements. It was unnecessary to dwell longer upon that conclusion, the importance of which was obvious to naval architects.

Sir John H. Biles said the paper by Mr. Lovett carried one back to a paper he (the speaker) read in 1894 before the meeting held in Southampton, in which only a simple case was taken, increasing dimensions with draught constant and draught increased in proportion to length; the cost per ton of freight carried was gone into and the advantages of a large draught were shown. Another contribution, made before the Dominions Royal Commission, considered in detail what could be done for carrying cargo at cheaper rates, among other points. In his Southampton paper he had shown the advantages to be gained, for the same speed, by increased draught, and that increased length was also an advantage. He had been taken to task for referring to ships of 1,000 ft. and depths of channels up to 60 ft. The Dominions Royal Commission decided upon depths of 40 ft. All harbours dealing with ocean traffic should be standardised in depth. The author had claimed a minimum depth of channel of 32 ft., presuming that for a large proportion of ships this would be most suitable, but the author's statement in this respect should not be read as conveying the impression that 32 ft. was a limit as to depth. (Here, Sir Eustace T. d'Eyncourt stated that the Suez Canal had increased depth to 33 ft.) Sir John said the reason for this was no doubt to be found in the competition of large ships which took the Cape Route. In regard to the present shortage of fast ships indicated by the author, this no doubt could be traced to cost of construction, lack of money, the cost of construction involving high passenger rates and decrease in traffic. When conditions improved and prices returned to their former level, cost of construction would be less and rates would also decrease. But this did not preclude the determining of any condition making for the improvement in ships' conditions, and under this head the length of voyage came in as well as power, speed and fullness. Length of voyage was a determining factor as regards mean displacement on the voyage, and that displacement differed for different lengths of voyage. He congratulated the author for having put on record the large amount of work which the paper had involved.

Mr. E. V. Telfer said that after studying the work of Taylor he used the standard coefficient with correction for beam. Mr. J. Tutin referred to his paper read at the spring meeting on the "Economical Efficiency of Merchant Ships." In our present state of knowledge, he added, it seemed difficult to arrive at anything greater than the present economy. The author had given a number of conclusions, but there was no indication as to whether the modifications indicated would be worth while. He (the speaker) thought that the author's conclusion to the effect that it was no disadvantage to increase beam if necessary for stability might have been better expressed otherwise, since stability for a ship was the primary condition. The block coefficient was a most important factor, and the author's work would have gained largely in usefulness had this been elucidated more fully.

In the course of his reply, Mr. Lovett welcomed the criticism made by the younger members of the Institution, which was quite good. He thought the words of the title should not be lost sight of. In regard to giving more time to the question of block coefficient, he would simply state that his table on the particular point had taken him more than one year to do. The work leading up to

that table (Table VI in the paper) was right, and he felt sure it would be found useful by all engaged in shipbuilding. He had referred in his verbal remarks to "smooth water" and this expression had been queried by Mr. Tutin; it was well understood in the trade, any vessel going, say, to India, and running on other trade routes was said to run in "smooth water." In the matter of the coefficient mentioned by Mr. Telfer, his (the author's) was very near to the standard, the difference between the two was, in fact, infinitesimal. The draughts he meant were freeboard draughts, and the speeds usually trial speeds, and the speed on trial at low displacements would be obtained on the voyage on a mean displacement. The average draught in his table IX, giving the characteristic features of three ships of 12,000 tons deadweight and 11½ knots speed, was 28 ft. 9 in., and he had suggested a minimum depth of channel of 32 ft. for all important sea ports. The most interesting remarks which had been put forward by Mr. Doyère fully justified the writing of the paper, and he hoped to add to the printed proceedings his calculations in the matter of the cylindrical coefficient and critical speeds.

The chairman said that the paper contained a very large amount of most useful data in a small space; it had given rise to a most interesting discussion, and on his motion the author received the cordial thanks of the meeting. All the papers, in fact, were of great value; they and the discussions upon them had covered a very wide field, affecting the naval policy of both France and England. He was very gratified at the important part which both the French and Italian eminent naval architects had taken in the proceedings. In concluding, he thanked on behalf of the Institution all the French authorities, the Sorbonne and the Collège de France for their warm hospitality.

This vote of thanks was seconded by Sir Eustace T. d'Eyncourt, and after a few graceful words by Captain M. Boris, C.M.G., of the French Corps of Naval Architects, the proceedings, which had been regularly attended by the chief engineers of the Chantiers de St. Nazaire, Chantiers de la Loire, and other French yards, came to a close.

Receptions and Visits.

On the afternoon of the 4th inst. the President of the French Republic received at the Elysée Palace a delegation of the Institution, consisting of the President and 16 members of Council, with Mr. Dana, the secretary. M. Millerand expressed his pleasure at the visit of the Institution to France on this first occasion since the war. Both he and the Duke of Northumberland laid stress upon the value of such gatherings, which helped in promoting still further the good relations between the two countries. There was also a reception by M. Bertin at his residence, and an official reception by the Minister of Marine in the evening.

A number of members proceeded to Reims on Friday the 7th inst., when the President laid a wreath on the recently erected memorial to the French soldiers who had lost their lives whilst serving in the tanks near Berry-au-Bac. The monument had been unveiled the previous week by Marshal Foch. The party also made a halt at the monument erected to the memory of the 42nd Regiment (Devons), where they read the inscription paying a high tribute to the gallant stand of these troops, when over 500 officers and men laid down their lives in defending the position between Berry-au-Bac and Craonne. In the course of the visit to Reims the party were driven through the town and witnessed the terrible havoc done during the war, of which evidence is still so apparent on every side. They then proceeded to the establishment of Messrs. Pommery and Greno, where they were received by the Marquis de Polignac, and shown over the extensive and interesting cellars which constitute the headquarters of the principal industry of the district. The party were then entertained to lunch by the Association Technique Maritime, M. Bertin presiding. Speeches were made by M. Bertin and by the Duke of Northumberland, the latter proposing the health of Mr. Dana, secretary of the Institution, to whose organising skill the success of the Paris meeting was so largely due.

On Saturday, the 8th inst., members of the Institution to the number of about 60, went to Havre, and were met on arrival by Mr. Augustin Normand, and after visiting the Normand shipyard they proceeded to the Palais des Régates, where a lunch was given by the Havre Chamber of Commerce, Mr. H. du Pasquier, President of the Chamber, occupying the chair. Mr. du Pasquier welcomed the members in the name of the Chamber of Commerce, the Sous-Préfet in that of his district, and the Maire of Havre in that of the municipality. The Duke of Northumberland replied, and Sir John Biles in a felicitous speech, also thanked the authorities of Havre for the splendid welcome given to the Institution, and expressed the high appreciation in which the members held the Duke of Northumberland, their President, for having throughout the meetings given them the proof of his exceptional capabilities as a leader, and for having further, by his admirable speeches, cemented the friendship between shipbuilders and marine engineers of both countries. A letter addressed by Vice-Admiral Sir Roger Keyes to Mr. Dana was read, expressing the admiral's regret at having been unable to join the Institution's meetings.

Visits then took palce to the Harfleur and Forges et Chantiers yards, also the artillery works and grounds belonging to Messrs. Schneider & Co., where an excellent tea was provided for the visitors.

On Monday, the 10th inst., a small party of members who could do so, proceeded to Caen, where they visited the Chantiers Navals Français; they were welcomed by the managing director, Mr. Ziegel, and the local manager, Mr. Roger. A lunch was given, at which Mr. Summers-Hunter, member of council, and Mr. Dana replied on behalf of the Institution. After a short visit to the shipyard the party proceeded to the adjoining steel works of the Société Normande de Métallurgie, where they inspected the large and modern plant of that company. They were then conveyed by motor cars to Trouville to enable them to return by the night boat to Southampton.

At the conclusion of the proceedings telegrams were dispatched by the Duke of Northumberland to the Minister of Marine and to M. Bertin, thanking them for the most cordial reception which had been accorded to the Institution during the visit to France.

Standard Specifications for Lubricants.—Messrs. Mavor and Coulson, Limited, in their *Machine Mining Magazine*, draw attention to the crying need for standard specifications for lubricants. The want has long been recognised, but difficulties have arisen from our limited knowledge of the essentials of a good lubricant, an ignorance which is shared even by leading makers of such commodities, who have at times gone seriously astray in attempting departures from established practice. Very much has, however, been learnt during the past six years, and it may well be hoped that within the course of the next few years it will be possible to draw up standard specifications for lubricants which have a rational and not merely an empirical basis. In the meantime, however, our machinery must be kept running, and the specifications of the United States Bureau of Mines, as amended March 1 last and issued by the Bureau as Technical Paper No. 305, will undoubtedly prove welcome. One of these specifications, relating to an oil suitable for the general lubrication of engines and machinery, is reprinted in No. 11 of Messrs. Mavor and Coulson's magazine.

Statistics on Mine Haulage and Cutting Machinery in the United States.—Statistics compiled by the United States Bureau of Mines, covering 7,088 coal mines operating in 1921, show that 5,064 mines, or more than 71 per cent., were using animal haulage. Rope haulage was reported by 1,066 mines or 15 per cent. of the total. Electric haulage was reported by 3,274 mines (46·2 per cent.), and the number of motors in use was 11,265. Compressed-air locomotives were used in but 1·2 per cent. of coal mines. Storage-battery locomotives were in use in 9·8 per cent. of the mines, the figures showing 693 mines with 1,428 locomotives. A total of 405 gasoline locomotives was reported by 271 mines, the number of mines representing 3·8 per cent. of the total. Steam locomotives numbering 1,069 were reported in use at 528 mines and pits, which is 7·4 per cent. of the total. Coal was mined by hand in 3,332 mines, 47 per cent. of the total number. Electric cutting machines, 17,875 in number, were reported for 3,607 mines, which is 50·9 per cent. of all mines reporting. Compressed air machines were employed in only 288 mines, or 4·1 per cent., and the number of machines in use was 2,159. Stripping operations were shown for 146 mines. Serial 2,352, "Kinds of Haulage and Cutting Machines in Coal Mines," is obtainable from the Bureau of Mines, Washington, D.C.

THE HARFLEUR SHIPBUILDING YARD AND SCHNEIDER HAVRE WORKS.

The Harfleur Shipbuilding Yard, a branch establishment of the Société des Chantiers et Ateliers de la Gironde, Bordeaux, is on the canal from Havre to Tancarville, and communicates with the French State Railway system and with the Schneider engineering works at Havre by sidings. It is illustrated in the plan Fig. 1, the references to which are the following:—A, offices; B, machine shop; C, plate and section shop; D, electric power station; E, general stores; F, woodworking shop; G, rigging shop; H, crane; J, workmen's dwellings. The illustrations, Figs. 2 to 5, on pages 73 and 80, are a general view of the yard, a view of the shipbuilding berths, and views in the plate and section shop.

The yard, which formerly belonged to anothes French company was acquired by the present owners and was reorganised in the year 1920 on modern lines for the rapid construction in seriel of comparatively smaller craft, the larger navar units being constructed at the Chantiers et Ateliers de la Gironde, at Bordeaux. The Harfleur yard

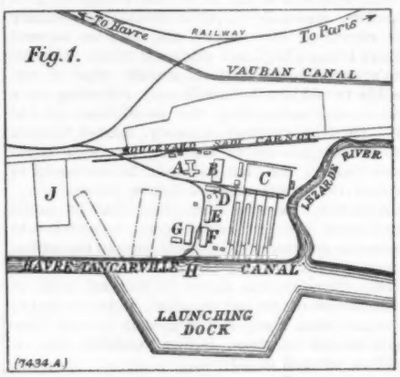


Fig. 1.

works in conjunction with the one at Bordeaux, and with the du Temple establishments, Cherbourg, also connected now with the Gironde Company, the Cherbourg establishments supplying both the Bordeaux and the Harfleur yards with the boilers, plate and structural work they require. All three works are provided with rolled steel plates, sections, engines, machinery and other material by the various establishments belonging to Messrs. Schneider and Co.

The Harfleur yard has an area of 320,000 sq. m. (380,000 sq. yards) of which one-eighth is covered by the various shops and buildings. It employs between 1,000 and 2,000 operatives according to the orders on hand. The speciality of the yard is the construction of hulls, the ships being engined complete when afloat. The first cargo boat of a series built at Harfleur, the Mécanicien Principal Carvin, of 6,800 tons deadweight capacity, was launched last November.

The plate and section shop has an area of 11,000 sq. m. in seven bays, each having the necessary machine tools and gear for executing the work in regular progression. A moulding loft is on the first floor. There are four shipbuilding berths side by side, 160 m. (525 ft.) in length, served by cranes and gantries. In order to secure the safe launching of the units built at the yard, the Tancarville Canal has been widened opposite the berths, where a launching dock having an area of 8 hectares (20 acres) has been provided for. There are two anchoring berths, one served by a 60-ton crane, for completing the ships afloat. All the forge and mechanical work required in ship construction is carried out in a machine shop shown in the plan, Fig. 1. The necessary joinery is done in a woodworking shop, also shown in the plan. The current required throughout the yard is received at an electric station at a pressure of 20,000 volts, where it is transformed down for power and lighting. Compressed air and water under pressure are delivered to different parts of the yard and to the ships in course of construction on the berths. The Tancarville Canal insures communication by

SOCIÉTÉ DES CHANTIERS ET ATELIERS DE LA GIRONDE: HARFLEUR YARD.

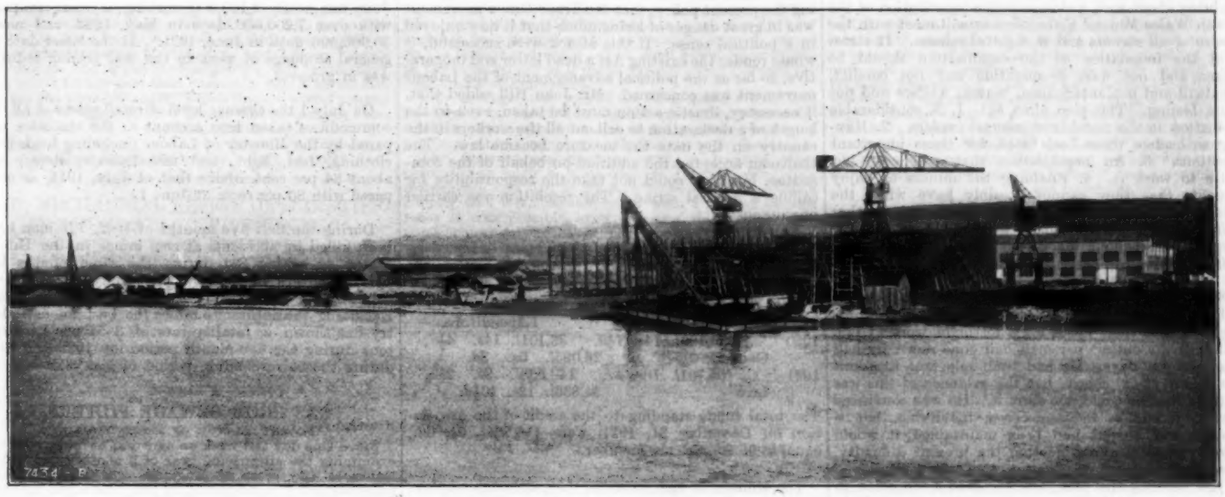


FIG. 2. GENERAL VIEW OF YARD.

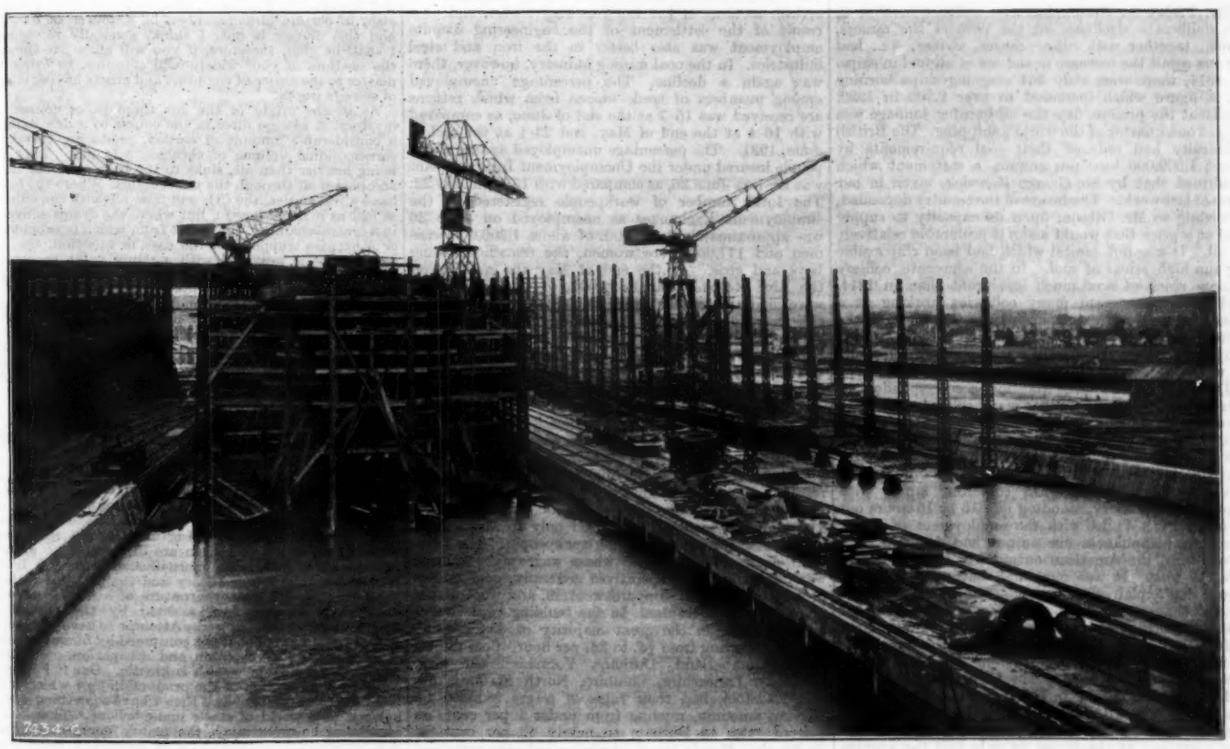


FIG. 3. SHIPBUILDING BERTHS.

water of the yard with the port of Havre and the whole estuary of the Seine.

The Schneider engineering works at Havre referred to in the foregoing are the artillery establishments which we described in a former issue (see ENGINEERING, vol. lxvii, page 308). These establishments up to the time of the armistice were extremely busy in the manufacture of guns of all calibres and munitions of every kind for use in the late war. For the last year or two they have put a part of their extensive plant to use for the construction of Diesel and steam engines for ship propulsion, and of spirit motors for lorries, motor 'buses and agricultural tractors. They have also undertaken the building of heavy aeroplanes of a powerful type. They carry out, further, the manufacture of electric motors of comparatively small powers and electric fittings. Ship joinery, moreover, now forms a part of the activities of these establishments. A special plant has been put down for the repair of locomotives and the manufacture of new component parts of these latter engines.

EFFICIENCY TESTS OF GOVERNMENT AUTOMOBILE ENGINES.—The United States Bureau of Mines report that after a course of experiments in the adjustment of carburettors on motor trucks used for hauling coal from the Government fuel yard, operated by the Bureau of Mines in Washington, D.C., made by G. W. Jones, assistant explosives chemist, a saving of 25 per cent. in the consumption of gasoline was effected. Mr. Jones found nearly all of the machines using a mixture too rich in gas. Before the adjustments, the exhaust gas was found to run 5·8 per cent. to 12·3 per cent. carbon dioxide. All machines were adjusted to give 11 per cent. to 12 per cent. carbon dioxide at a speed of about 5 m.p.h., the usual speed for the trucks. On level lines the carbon dioxide dropped about 1 per cent. under that on upgrades. A fleet of 40 motor trucks is used by the Government fuel yard, these being mostly of 5 tons and 7½ tons capacity. Complete records of the service given by the trucks are kept. The volume of gasoline consumption is considered to have been affected by three factors, namely: 33 per cent. due to the engine, 33 per cent. to the carburettor adjustment, and 33 per cent. to the driver.

INDUSTRIAL NOTES.

THE *Western Mail* has given publicity to an appeal addressed by two miners of South Wales to their fellow-workmen, the object of which is to endeavour to bring about such a change in the constitution of the South Wales Miners' Federation as will meet with the desire of all serious and thoughtful miners. It states that the foundation of the organisation should be peace and not war, co-operation and not conflict, goodwill and not antagonism, mutual welfare and not class feeling. The plan aims at: 1. A considerable reduction in the number of miners' leaders. 2. Having as leaders those best fitted for these important positions. 3. An organisation that will cost but little to work it. 4. Enabling the miners to enjoy benefits that they cannot possibly have while the wealth of the industry is wasted in strife and other things. We trust the appeal will meet with a ready response throughout the district, and that the lead will be followed in other industries in the country.

Speaking recently at a meeting of miners at Brierley Hill, Mr. J. G. Hancock, M.P. (Belper), said the owners declared that their losses for a fortnight were £1,129, and that the output per man had gone down by half since pre-war days. He had been reluctant to admit the charge of ca' canny, but the evidence of this was so clear that he could not deny it. He was convinced that a reduction in wages was inevitable, but if the pre-war output had been maintained, it would have gone far towards meeting the present difficulty. According to later information, the miners employed at the Brierley Hill pits have accepted a reduction in wages to avert the closing down of the mines which, otherwise, would have taken effect at the commencement of the present week.

Mr. Finlay A. Gibson has also called attention to the deliberate slackness on the part of the miners, which, together with other causes, strikes, &c., had for one result the increase in the use of oil fuel in ships. In 1914, there were only 364 seagoing ships burning oil, a figure which increased to over 2,300 in 1920, whilst at the present day the oil-burning tonnage was almost one-quarter of the world's shipping. The British Admiralty had reduced their coal requirements by about 1,000,000 tons per annum, a statement which confirmed that by Sir George Renwick, given in our issue of last week. The future of the country depended, according to Mr. Gibson, upon its capacity to supply coal at a price that would make it preferable relatively to oil. It was not capital which had been responsible for the high prices of coal. In the aggregate, colliery owners received now much less profit than in 1914, and there were even many collieries working at a heavy loss. The greater part, if not the whole of the increased cost, was due to higher labour cost in the shape of a direct increase in wages and reduced hours of working.

Dealing with this same question, a correspondent of *The Yorkshire Post* states that many collieries are to be closed down indefinitely. Some pits have recently been losing as much as 5*s.* and 6*s.* per ton. Forty years ago the output was 6 tons per miner per week; now, with much better plant and machinery, it was only 4 tons. We had splendidly-equipped collieries, mines with expensive machinery, standing idle 15 or 16 hours out of every 24. Whilst with the employment of better mechanical appliances our output had declined from 6 to 4 tons, the American output had increased from 8 to 18 tons. It was our small output per unit of labour that explained the trouble. Miners took so much time off that one of their own leaders publicly admitted that "unjustifiable absenteeism was losing the country 26,000,000 tons of coal per year." After the war, hours of labour were curtailed; customers and would-be customers were driven away by high prices and short and irregular supplies; in 1920, we had a big national coal stoppage; in 1921 we had a still more protracted stoppage; last year, we raised 150 tons of coal per man employed at the mines, or only half the average of 40 years ago.

It is reported that the membership of the Amalgamated Engineering Union has dropped from 440,000 to 394,000 during the past twelve months, there having been a reduction of between 7,000 and 8,000 members during the last month.

At the annual conference of the General Federation of Trade Unions, held in Dumfries at the end of last week, a resolution was passed "viewing with regret the action of the Government in their refusal to confirm by legislation the agreement concluded at the Washington Conference for the reduction of working hours to not more than 48 per week, and urging upon trade unionists to resist any departure from the existing trade agreements dealing with the hours of labour." Mr. A. Short, M.P. (Wednesbury), moved a resolution condemning the Bill now before Parliament to amend the Trades Union Act; he urged the importance of unanimity in fighting to maintain the rights and privileges already won. He was satisfied from his experience in the House of Commons and the attitude of those who were pursuing the present policy, that the Trade Union movement was in great danger of losing much that it now enjoyed in a political sense. If this attack were successful, it would render the existing Act a dead letter and inoperative, so far as the political advancement of the Labour movement was concerned. Mr. John Hill added that, if necessary, drastic action must be taken, even to the length of a declaration to call out all the workers in the country on the date the measure became law. The chairman accepted the addition on behalf of the committee, but they could not take the responsibility for calling a general strike. The resolution was carried unanimously.

The 50th annual report for 1921, recently issued by the United Patternmakers' Association gives the following figures for that year compared with those for the preceding year:—

		Income.	Expenditure.
1920	....	59,196*l.* 14*s.* 7½*d.*	33,101*l.* 14*s.* 4½*d.*
	Gain		26,095*l.* 0*s.* 3*d.*
1921	....	55,701*l.* 16*s.* 4*d.*	140,538*l.* 9*s.* 2½*d.*
	Loss		84,836*l.* 12*s.* 10½*d.*

The total funds standing to the credit of the Association on December 31, 1921, were 116,764*l.* 0*s.* 3*d.*, equal to 9*l.* 3*s.* 2½*d.* per member.

The Minister of Labour states that, although employment generally was still bad during June, the continuous improvement which had been in progress since February was maintained. A further improvement was reported in the textile and clothing trades, and in certain sections of the woodworking trades, and as a result of the settlement of the engineering dispute employment was also better in the iron and steel industries. In the coal mining industry, however, there was again a decline. The percentage unemployed among members of trade unions from which returns are received was 15·7 at the end of June, as compared with 16·4 at the end of May, and 23·1 at the end of June, 1921. The percentage unemployed among workpeople insured under the Unemployment Insurance Act was 12·7 on June 26, as compared with 13·5 on May 22. The total number of workpeople registered at the Employment Exchanges as unemployed on June 26 was approximately 1,455,000, of whom 1,206,000 were men and 177,000 were women, the remainder being boys and girls. At the end of May the number on the Live Register was 1,522,000, of whom 1,238,000 were men and 204,000 were women. A small part of this decrease is due to the temporary exhaustion of insurance benefit. The number of vacancies notified by employers to Exchanges and unfilled on June 26 was 16,500, of which 3,000 were for men and 11,600 for women, compared with 17,700 on May 29.

There was a further fall in wages during June. In those industries and services for which statistics are compiled by the Ministry of Labour, changes in rates of wages reported as having taken effect in June resulted in a total reduction of over 390,000*l.* in the weekly full-time wages of nearly 2,000,000 workpeople. The increases reported amounted only to about 100*l.* in the weekly wages of 5,000 workpeople. The principal classes of workpeople whose wages were reduced were building trade operatives generally, coal miners in various districts, shipyard workers, and wool textile operatives in Yorkshire. In the building trade wages were reduced, in the great majority of districts, by amounts varying from ¾*d.* to 2*d.* per hour. Coal miners in Northumberland, Durham, Yorkshire, the East Midlands, Lancashire, Cheshire, North Staffordshire, and Radstock had their rates of wages reduced by varying amounts, ranging from under 1 per cent. on current rates in Durham to nearly 12 per cent. in Radstock. Men in the shipbuilding industry sustained a reduction of 3*s.* a week. In the wool textile industry in Yorkshire the "cost-of-living" wage was reduced from 85 to 75 per cent. in the case of timeworkers, and from 69·54 or 73·409 per cent. to 65 per cent. for pieceworkers. Since the beginning of 1922 the changes in rates of wages reported to the Department have resulted in a net reduction of over 2,700,000*l.* in the weekly rates of wages of about 7,150,000 workpeople.

The number of trade disputes involving stoppages of work reported to the Ministry as beginning in June was 32. In addition, 50 disputes, which began before June, were still in progress at the beginning of the month. The dispute in the engineering industry, however, which began on March 13, was settled during the month. The total number of workpeople involved in all disputes in June (including those workpeople thrown out of work at the establishments where the disputes occurred, though not themselves parties to the disputes) was about 310,000, as compared with 370,000 in the previous month, and 1,550,000 in June, 1921. The estimated aggregate duration of all disputes during June was nearly 2,100,000 working days, as compared with over 7,200,000 days in May, 1922, and nearly 30,000,000 days in June, 1921. At the latter date the general stoppage of work in the coal mining industry was in progress.

On July 1 the average level of retail prices of all the commodities taken into account in the statistics prepared by the Ministry of Labour (including food, rent, clothing, fuel, light, and miscellaneous items) was about 84 per cent. above that of July, 1914, as compared with 80 per cent. at June 1.

During the first five months of 1922, 722 men have been killed by accidents at coal mines in the United States, as against 831 during the same months last year, resulting in fatality rates of 3·90 and 4·15 respectively, per 1,000,000 tons of coal produced. Excluding the anthracite mines the bituminous industry has shown a fatality rate of 3·54 per 1,000,000 tons during the five-month period of 1922 and 3·67 during the corresponding period of last year.

GAS FROM SEWAGE FILTERS.

TO THE EDITOR OF ENGINEERING.

SIR,—One day last week an assistant of mine, who was examining the alternating gear of a contact bed installation in the West of England, was attacked, and rendered nearly unconscious, by gas. The works manager then informed him that the same thing had happened to him. In all my previous experience of sewage filters, extending over 26 years, I have never heard of a case of the kind, though the risk of explosion of tank gas is well known. It is evident, however, that filter gas may also, in certain circumstances, be a source of danger; and this danger is not, I think, generally recognised. I shall be glad, therefore, if you will allow me through the medium of your widely-read columns, to bring the matter to the notice of engineers and others having charge of sewage works.

As to the origin of the gas there is, of course, no mystery. A sewage filter in the course of a day oxidises a considerable amount of carbon, producing thereby a corresponding volume of carbonic acid gas. This gas, being heavier than air, sinks to the bottom of the filter, and passes off through the underdrains. Where the latter have a free outlet, the CO_2 will flow off with the effluent as fast as it is produced; but where the drains converge in a central chamber, the outlet from which is submerged or otherwise trapped—in the case in question, the discharge pipe is provided with a reflux valve to protect the filters from flooding—the gas may be unable to escape, and will accumulate in the lower part of the chamber.

Although CO_2 is not actually poisonous, it will not support respiration; and if present in sufficient quantities, may cause death by suffocation. Those who have occasion to work in chambers in which this gas is liable to collect should, therefore, be warned not to stoop down in them without first testing the air in the bottom of the chamber by means of a light.

Yours faithfully,

ARTHUR J. MARTIN.

44, St. George's Square, Westminster, S.W.1. July 17, 1922.

STATIC THEORY AND KINETIC FACT.

TO THE EDITOR OF ENGINEERING.

SIR,—Sir Robert Hadfield's calculation, to which you refer in an interesting leading article this week, that some 29,000,000 tons of iron are dissipated per annum in the form of rust, is one more illustration of the difference between economic theory and the physical reality.

Material wealth is in the nature of a flow from production to consumption, assisted by the regulating action of purchasing-power. Attempt to save it, and it rots or rusts away, *i.e.*, if not consumed by human beings, it is consumed by attrition and dissipation. In other words, the reality of wealth is kinetic. But if I have a *claim* on that portion of the production-flow which may be termed "capital goods," then I have something which belongs to a world of static make-believe. That claim continues, however much the reality may rot or rust and eventually disappear. It is, indeed, a miracle of immortality in a universe where "worlds on worlds are rolling ever, from creation to decay." In short, it is a case of eating one's cake and having it.

Now note how the discrepancy is overcome. Man is still far from being a reasoning animal, and instead of adjusting his claims into accord with the reality, he attempts to throw an appearance of static permanence over the world of fact. Thus, when consumption goods are sold, they are made to bear the cost of continuously replacing the attrition losses of capital goods, by including in price of consumables an item for "depreciation" or "liquidation of capital cost." In other words, the public pays for the whole production flow, but only gets delivery of the consumable goods; the balance going to support the economic fiction of "fixed" capital—that wealth is static in nature and can, therefore, be saved and accumulated indefinitely.

There is naturally under these circumstances a rush to establish claims, with the result that we now find our civilisation suffocating under a vast mass of paper entanglements, claims far in excess of the wealth really

available. And so pre-occupied is mankind with these paper claims that the stream of real wealth dwindles away before our eyes. We throw away the substance for the shadow—if I may be allowed so to mix my metaphors. No wonder that Mr. J. M. Keynes, in his *Economic Consequences of the Peace*, recommends a general bonfire of such claims as a preliminary to European recovery.

Economics claims to be a science. It is not, and never can be, so long as it is based on static assumptions. Economists, captains of industry, and labour leaders may discuss and argue interminably: but until they come down to the fact that finance is based on statics, whereas the physical reality which finance would control is a matter of kinetics, their labour will be spent in vain.

Yours faithfully,

HUGH P. VOWLES.

65, Northgate-street, Gloucester. July 18, 1922.

"THE MECHANICAL DESIGN OF SCIENTIFIC INSTRUMENTS: KNIFE-EDGES."

TO THE EDITOR OF ENGINEERING.

SIR,—The articles on "The Mechanical Design of Scientific Instruments," in your recent issues have greatly interested me. In your issue of June 23, Professor Alan F. C. Pollard remarks, on page 794, about half-way down first column, when speaking of knife-edges: "Where only two surfaces of constraint were required for a knife-edge, such a knife-edge could be replaced by the contact of two steel balls, rigidly connected together bearing on a plane; such an edge was useful when the radius required to be accurately known."

There is, however, another important property which such an "imaginary edge" has, which extends between the two balls' contact-points in the bearing plane, when comparing this with two knife-edges in line, which property is often overlooked, namely, that such a "virtual knife-edge" is the only one in which the line of contact will always be the same and is, as it were, of perfect imaginary contact. Any other set of two knife-edges used can never be brought into perfect alignment. I will refer to this later on.

The use of two steel balls as a knife-edge is a direct practical application of the well-known geometrical axiom stating:—Through two points there is "one, and only one line" possible.—The load must be assumed small enough, of course, to allow the balls' contact points to be considered as geometrical points.

We make use of such an invariable edge in our small rotary body balancing machines assuming it to obey this axiom. (A description with illustrations (see Fig. 5) of this machine appeared in ENGINEERING of December 31, 1920.) When dealing with apparatus which have to carry greater loads "ball points" cannot be made which will stand up to this, and one has perforce to revert to knife-edges.

A case in point was the following: My father, the late engineering manager of the Royal "De Schelde" Dockyard at Flushing, Holland, carried out some investigations privately in which I had the privilege to assist during 1915–16, which led to the design of his balancing machine for turbine rotors, &c. This has since been fully protected over here and elsewhere. The machine was also described in ENGINEERING of December 31, 1920. Owing to the trade depression this machine has not met yet over here with the success it might be thought to deserve. During these investigations we soon realised the impossibility of making a set of knife-edges which would remain in the constant alignment which was necessary when acting as a fulcrum to a balance beam, and even if it could be done to remain in alignment before and after a heavy rotor had been put on the beam.

The obvious and only way in which my father solved this difficulty was to design a machine working on a single knife-edge, which, when under load, would not bend and thus remain in full-line contact with its bearing blocks, ensuring true alignment and preventing the crushing of its edge. Before describing this edge I would just refer to the following:

On page 794, in second column of ENGINEERING of June 23, Professor Pollard draws attention to the beautiful design of Sir Horace Darwin's knife-edges, in which two sets of knife-bearing planes were provided, rotatable about axes at right angles to the direction of the edge so that when the edges bent, under load, these planes rotated, maintaining line-contact with the edges, all as explained in your Fig. 21.

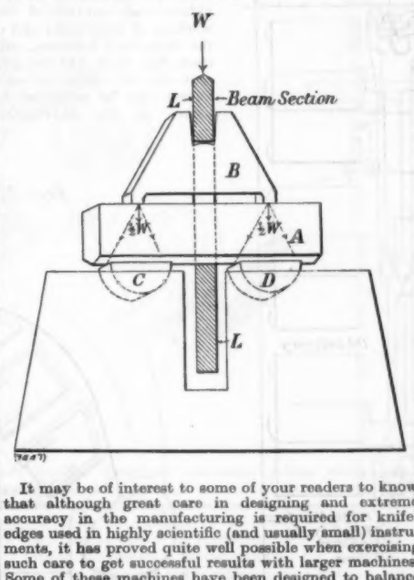
It is, of course, possible I do not understand this quite rightly, but as I read it, I fail to see how, when weight is imposed on the knife-edge bending same, why ever this would then bear on the four rotatable bearing planes; in fact, from the foregoing it seems plain that the knife-edge will in fact never, not even without load, bear equally on these four edges. No machinery to-day, however accurate, could accomplish the desired result, to my mind. To get two bearing planes in good contact with one edge is a bad enough problem.

After reading the above I decided to publish details of the edge designed by my father and used in our apparatus, which I believe meets most of the difficulties encountered in such knife-edges. In this knife-edge A (see sketch) an attempt was made to distribute the load equally over its bearing length and to prevent the bending of the knife proper. This was the more necessary as our knife-edge had to act as the fulcrum axis of a sensitive large balance beam.

The load W, consisting of a balance beam, carrying at one end a turbine rotor and counterweights on its other end (a total weight of 10 tons or more), was made to bear on a curved upper part of a shouldered yoke-piece B, having two equal limbs, which in their turn imparted half the weight W on the top of the solid knife-edge A at two points midway above the two semi-circular bearing blocks C and D, which had rounded backs, allowing them to revolve in a plane perpendicular to the direction of the edge. There was thus no tendency for the knife-edge to bend as the load on it was equally distributed, while any displacement which might take place due to other causes, distortion, &c., could always be taken up by the revolvable bearing blocks, so that the constant contact of the edge was ensured. The yoke-piece B and the knife-edge A were rigidly held together in a frame while the balance lever L rested on the former and could adjust itself freely by swinging on the rounded top of B in the vertical plane through the length-axis of knife-edge.

This arrangement proved to be a perfect one, and I believe I am justified in considering it a very beautiful solution of an interesting and, at first, rather perplexing problem, when remembering the weight to be dealt with.

The sensitiveness obtained with a balance lever swinging on such a knife-edge as fulcrum was truly remarkable and had to be seen to be believed. When loading this 9-ft. balance beam with a 10-ton turbine rotor it was possible, after bringing this system into equilibrium by means of counterweights, to "blow" this heavily-loaded beam off its zero position by one's breath! In other words, a few grammes were sufficient to upset the equilibrium of many tons.



It may be of interest to some of your readers to know that although great care in designing and extreme accuracy in the manufacturing is required for knife-edges used in highly scientific (and usually small) instruments, it has proved quite well possible when exercising such care to get successful results with larger machines. Some of these machines have been designed to balance bodies of 75 tons or more to within a few ounces. Such an edge might often prove useful in small scientific instruments also.

The two-ball type of knife-edge for small loads we have applied for the balancing of gyro-wheels of gyro-static compasses, which also gave astonishingly good results. We found it possible, in fact, to detect an eccentricity of one hundred thousandth part of an inch in a 5-in. diameter gyro-wheel of about 6 lb. weight, corresponding to an overweight at the wheel's circumference of a few milligrams! Trusting this may prove of some service, and thanking you for the space allowed me in your valuable paper,

I am, yours faithfully,

W. HAMILTON MARTIN, A.M.I.N.A.

Postbox 19, Flushing, Holland. June 30, 1922.

"THE FIRST STEP."

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with considerable interest the article on the "First Step," which appeared on June 2 (page 689), and also Mr. Free's comments on that subject contained in the issue of July 14 (page 44 *ante*). As Mr. Free and I were schoolfellows and entered upon our engineering careers at about the same time, a contrast between our widely different methods of training might prove instructive and form a basis for criticism and suggestion by the experts as to the ideal "First Step."

Mr. Free has made his method clear: a College training leading to a University degree at an early age. Speaking now of myself and of many colleagues, I have never seen the value of an all-day technical training, and have, therefore, reserved study for the evenings and spare time. Meanwhile, my day-time energies have been devoted to practice in the form of an apprenticeship with a large firm of first-class reputation, who, besides giving me a sound primary training in mechanical and commercial engineering, have afforded me every facility for and encouragement to study. By taking advantage of this latter, I am now an Inter. B.Sc. and in a position to take the full degree when necessary. The drawback to this method is the fact that it makes great demands on one's time and energies, and calls for sacrifice, which some firms are unable or unwilling to make, with the result that many apprentices, although they acquire practical skill, do not get far with the study which makes all the difference between the mechanic and the engineer. I am of opinion, however, that my method has saved me much valuable time, and that it is not out of the reach of any young man who enjoys normal health and who is determined to make a success of the career he has chosen.

I have now two questions on my mind, my answers to which will be obvious, but discussion of which might prove helpful to those who aspire to become engineers:—(*a*) Is the full-time College training, with its easy hours and long vacations, a necessity or a waste of time, leaving the graduate, as it nearly always does, too old to commence any recognised course of practical training, and with little prospect of initial salary outside the teaching profession? (By the way, is this good for the teaching of engineering subjects?) (*b*) Is a University degree of any value to a young man who has not the practical experience to justify his position as an engineer? I ask these questions for the benefit of engineering generally, and in order that young would-be engineers should obtain expert advice before "first stepping."

Yours faithfully,

HARRY O. PARRACK.

26, Khedive-road, Forest Gate, London, E. 7.
July 17, 1922.

TO THE EDITOR OF ENGINEERING.

SIR,—No doubt Mr. Free's letter on the above has had a sympathetic reading from many of the readers of ENGINEERING, but there seem to be one or two points on which a little more can be said. In the present depressed state of trade, there are very few firms who can fully employ men who have been with them for many years, and Mr. Free is only experiencing the difficulty in finding employment which is being faced by thousands (this is *not* a figure of speech) of qualified men. Obtaining two offers with 83 applications is by no means a bad average.

Engineering is, and has been for years past enormously overcrowded, and as technical colleges all over the country are turning out graduates far faster than the profession can assimilate them, the immediate future is not hopeful.

Even during the war there was no great shortage of technical men to undertake the administrative work, and, generally speaking, they satisfactorily filled posts of greater responsibility than they had had the opportunity of holding before. Quite a large number of these men are now looking for berths, and comparatively few are holding posts which they have proved themselves capable of holding. The fact was advertised in the columns of the technical papers a few weeks ago, that two vacancies existed in a Government Department for men not over 26, who should have D.Sc. degree, and preferably be honours men in either Civil Engineering or Electricity; salary to commence, £200 per annum. This should disillusion many as to the value of even a high degree by itself.

If a man goes into the shops for only a short time and in that time wants to get an insight into shop methods, moving from one department to another, he is not of any value to his employer, and can hardly expect to be paid for it any more than he would expect to be paid for attending lectures. In pre-war days, he would in many districts have paid a premium for the privilege. The usual apprenticeship of five years or so is slow and for the first year little beyond labouring work would be done. If a man wants to do the same work in less time, it follows the general rule of speed being expensive.

A very important point frequently overlooked is that time spent in the shops gives the opportunity of getting to know the workers personally and forming the habit of looking at matters from "the other man's point of view," and if the time in the shops does this, it has been valuable even though little engineering knowledge has been obtained.

As regards the suggestion that scholarships in workshop practice would pay the employer, as at present, for most of the smaller posts at any rate, the difficulty is not in finding the men to put forward, but to select the one best suited out of dozens of probably suitable men, it does not appear that there would be any advantage gained in doing this. I believe I am right in saying that when Sir Joseph Whitworth founded his scholarships, he intended them to be in part for workshop practice, so that both the skilled mechanic and the man of academic training could compete on equal ground and find the means of completing a balanced professional training. I understand the craftsmanship examination has now vanished.

I am, Sir, yours faithfully,

R. W. OSTELL PROSSER.

7, Willoughby-road, Hampstead. July 17, 1922.

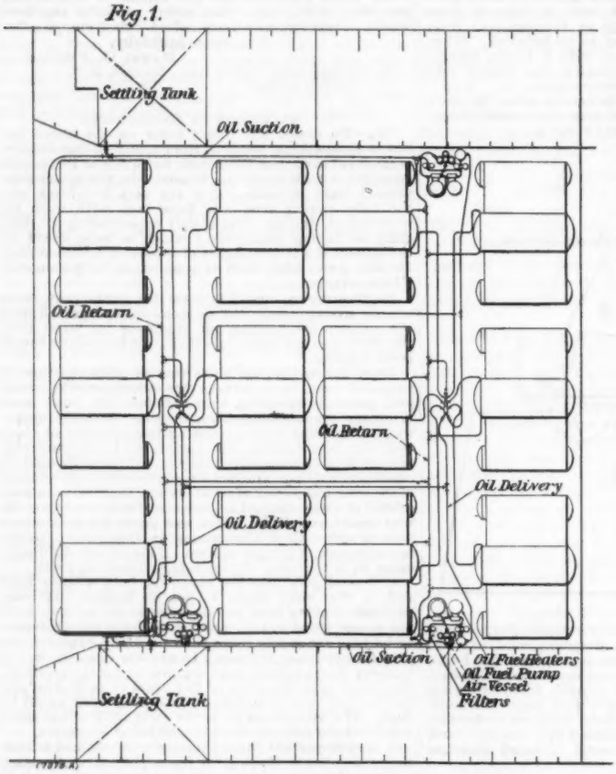
GERMANY AND BRITISH EXHIBITION POSTERS.—The attention of the Federation of British Industries has been drawn to certain communications which have been received from Germany asking for copies of propaganda posters issued at exhibitions and trade fairs in this country. The reason given for this request is that the posters are to be used as illustrations to a volume dealing with exhibition literature and advertisements. Investigations made show that there is grave doubt as to the purpose for which such posters, stamps, &c., are likely to be used, and any members receiving requests of this kind are asked to apply to the Federation in order that the *bona fides* of the inquirers may be looked into.

METALLURGICAL RESEARCH IN SWEDEN.—At the inaugural meeting of the Metallografiska Institutet of Stockholm held recently, it was announced that Sir Robert Hadfield, Bart., a Vice-President of the Federation of British Industries, had presented the Institute with a two-year scholarship of £150 per annum. This donation is given for the purposes of metallurgical research as "an expression of the debt of gratitude which the world owes to Swedish science."

THE OIL FUEL INSTALLATION OF THE "MAJESTIC."

WE have already given, on page 3 *ante*, a general description of the White Star liner Majestic, and in view of the excellent performance of the vessel on her maiden and subsequent voyages, the particulars of the oil fuel installation which we are now able to publish should be especially interesting. As mentioned in the article above referred to, steam for the turbines, which develop some 66,000 s.h.p., is supplied by 48 water-tube boilers of the Yarrow-Normand type having a total heating surface of 220,000 sq. ft. The working pressure is about 260 lb. per square inch, and the boilers are all equipped with Mumford's automatic feed-water regulators, which we understand have given entirely satisfactory results. Forced draught is employed, and the boilers are fired with oil fuel on the White low-pressure system. This system has been developed by the White Patent Oil-Burning Company, Limited, of Shadwell-street, South Shields, and has now been fitted on upwards of 1,000 ships with an aggregate horse-power of over 3,500,000. Among the vessels so fitted are the Cunard liners Berengaria and Aquitania and the White Star liner Olympic, and a detailed description of the installations on the two last-mentioned vessels will be found on pages 832 and 865 of ENGINEERING, vol. cix, and on page 23 of vol. cx. In these articles the principles of the system were fully explained, the various components being illustrated and described in detail.

Fig. 1.



In principle the equipment of the Majestic is similar to those of the Aquitania and Olympic, but the general arrangement is somewhat different, and a number of departures from earlier types of construction have been made in the more recent installation. It will, therefore suffice, on the present occasion, to explain the points of difference, referring our readers to the previous articles for particulars of the components common to the three installations.

The boilers of the Majestic are arranged three abreast in four boiler rooms, each including 12 boilers and two stokeholds. The plan of one of the boiler rooms reproduced in Fig. 1 is typical of all of them. The bunkers, which were originally designed and finished for coal, were subsequently adapted for oil fuel, storage and settling tanks being arranged along each side of all the boiler rooms as shown in Fig. 1. Suitable connections for the transfer of oil from the storage tanks for heating and settling are, of course, provided. The total oil-fuel storage capacity of the ship is approximately 9,000 tons, and about 5,700 tons are used per voyage. The equipment for each boiler room is entirely independent and, as shown in Fig. 1, comprises three separate pumping units with the necessary heaters and strainers; drawings of the two last-mentioned components will be found on Plate III, published with our issue of July 2, 1920. The pumps draw from the settling tanks and deliver through the heaters and strainers to a distribution box placed centrally in each stokehold; return pipes are connected to the pump suctions as will be clear from the plan. The piping arrangements are such that any of the pumps can draw from either of the settling tanks and deliver to either of the distribution boxes.

From the main distribution boxes, pipe connections run to the boiler fronts, an elevation of one of which is given in Fig. 2. On each boiler front another small distribution box is provided with connections to the five burners fitted to each boiler; the total number of burners on the ship thus amounts to 240. Special attention has been given to the important matter of providing easy control of the working of each boiler and of the individual furnaces, and, from Fig. 2, it will be seen that the oil supply to each burner can be regulated by valves on the distribution box. A quick-acting shut-off valve fitted in the delivery pipe to each boiler front should also be noticed. In case of emergency, this valve can be operated to isolate the particular boiler by the movement of a single weighted lever. Separate air-regulating hand wheels are also fitted for each burner as shown, and the flames can be observed by means of sight hole doors provided in the outer casings. The furnace fronts are of the conical air-regulating type, of an improved design, and they are supported on a firebrick-lined casing which is rigidly secured to the inner boiler-casing plates. A sleeve passing through the boiler outer casing plates acts as a further support for the front and also forms an efficient airtight joint. Air inlets, in the form of slots, are arranged round the periphery of the body casting, and a cover with corresponding slots is fitted over this. The cover, which is free to rotate, is operated by a rack and pinion so that the air inlets can be opened or closed as desired, a pointer, moving over an engraved plate fitted on the boiler front casing, being provided to indicate the extent of the air opening. The air supply, in passing through the slots, is given a rotary motion by means of an arrangement of internal vanes, in order to ensure a thorough mixture of the air and oil which results in perfect combustion.

A longitudinal section and an end elevation of the burner are reproduced in Figs. 3 and 4, respectively, and if these are compared with the corresponding illustrations of the earlier type of burner printed on Plate III of our issue of July 2, 1920, two modifications of details (which will be referred to later) will be noticed, although the general design remains the same. In the White system, the heated oil, which can be supplied to the burner at pressures ranging from 10 lb. to 90 lb. per square inch by adjusting the speed of the pumps according to the boiler power required, is atomised mechanically by the form of the burner tip. This, it will be seen, comprises a tip screwed on to the body and formed with an internal coned passage into which a part resembling a mushroom valve is pressed by a helical spring. The stem of the valve is hollow and is drilled with small holes, so as to form a strainer through which the oil passes on its way to grooves cut tangentially in the valve seating. The jets of oil passing through these grooves meet in the small conical space at the back of the tip, and are there broken up so that they emerge in the form of a hollow cone-shaped mist. In the earlier form of burner, the oil strainer was placed in the bend at the outer end of the oil supply pipe, and its incorporation in the inner end of the burner is one of the modifications above referred to.

The burner tip can easily be removed for cleaning purposes, an operation which has usually to be carried out about once in every 12 hours, and occupies only a few minutes; it can also be exchanged for another having a larger, or smaller, orifice if it is necessary materially to vary the quantity of oil consumed for the purpose of increasing or diminishing the power for long periods.

Fig. 2.

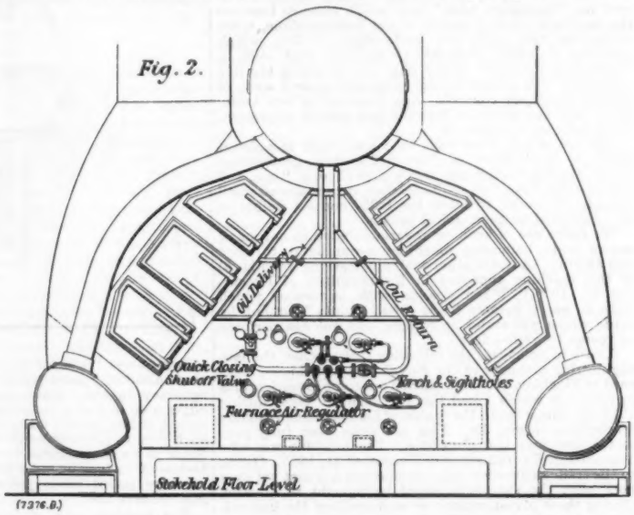


Fig. 3.

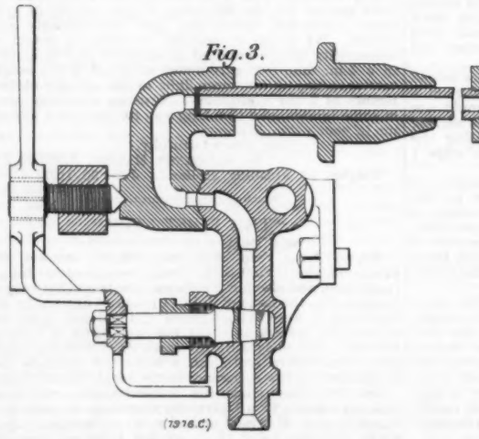
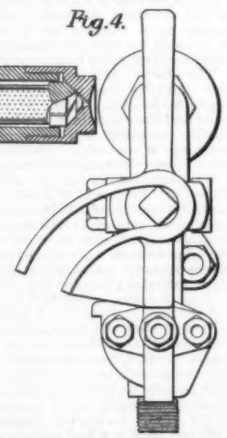


Fig. 4.



THE HILGER CHEMICAL SPECTROMETER.

CONSTRUCTED BY MESSRS. ADAM HILGER, LIMITED, LONDON.

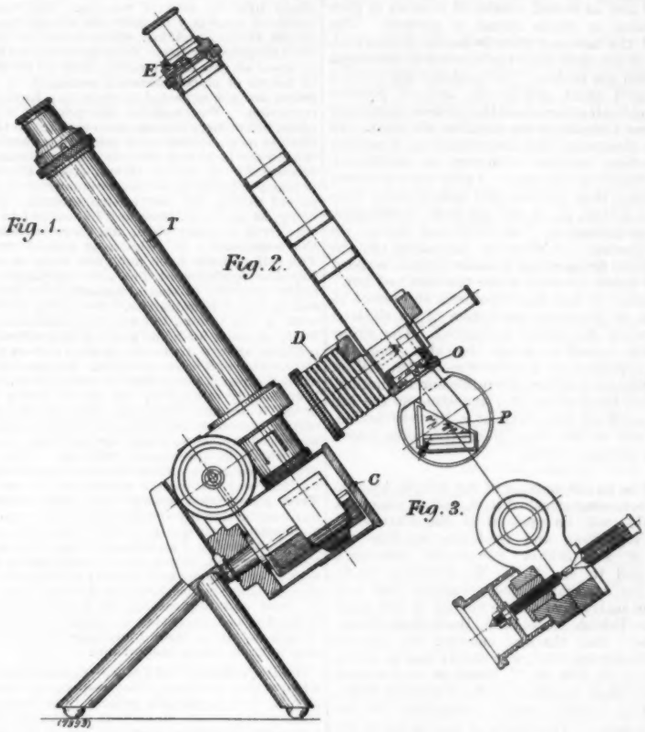


Fig. 1. Fig. 2. Fig. 3.

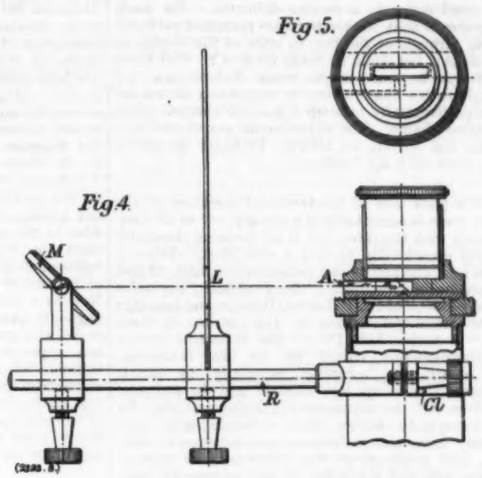


Fig. 4.

Fig. 5.

Reference to Fig. 3 will show that the burner body is held in position by means of a swinging shackle pivoted to a casting which is bolted on to the furnace front. The joint between the casting and the burner body is of the spherical metal-to-metal type, and it is kept tight by a pointed set screw carried by the swinging shackle. To remove the burner for cleaning, it is only necessary to slack back this one set screw and swing the shackle clear. It is, in connection with this operation, however, that the second modification above-mentioned has been made. To cut off the oil when taking out the burner, a plug cock is fitted in the casting, as is clearly shown in Fig. 3, and, in the new design, the handle of this cock is formed with a quadrant-shaped guard which covers the squared end of the set screw in the swinging shackle, to be seen in Fig. 4, when the cock is open. It is therefore impossible for the stoker to get at the set screw for the purpose of removing the burner without first closing the cock. The arrangement thus constitutes a simple and effective safety device which entirely prevents the serious consequences which might otherwise ensue from the escape of the heated oil if the burner were inadvertently removed with the oil supply on.

On extended tests the boiler installation has proved very efficient, the evaporation obtained being 16·5 lb. of water, from and at 212 deg. F., per pound of oil consumed, the oil used having a calorific value of 18,500 B.Th.U. per pound; in this test the CO_2 in the gases in the uptake remained fairly constant at 14 per cent. The installation has evidently worked satisfactorily under normal running conditions at sea, since on the vessel's maiden voyage, a mean speed of just over 22¾ knots was attained for the whole trip. On the return journey the average speed between the Ambrose Channel Light and the Eddystone Light was 24·2 knots, as mentioned in our previous article, and it will therefore be extremely interesting to see what results are obtained in a few months' time.

THE HILGER CHEMICAL SPECTROMETER.

CONSIDERING that Bunsen and the chemists had a greater share in the early application of spectrum analysis than had his colleague Kirchhoff, who deduced the fundamental laws of light emission and absorption, and other physicists, it is rather surprising that chemists and metallurgists still make comparatively little use of the spectroscope. The presence, especially of certain rare elements, is ascertained by means of the spectroscope; the metallurgist looks for the cyanogen lines in the Bessemer converter flame, and some chemists in America and elsewhere have attempted to make quantitative spectroscopic estimates in routine analysis after the manner of colorimeter tests. But the spectroscope might be rendered much more generally useful, for instance, in determining the end point of a reaction as well as the completion of a washing-out process, for which purposes colour indicators are mostly preferred.

The restricted application is not usually so much due to the fact that the spectra are complex and variable, and that one element may mask the presence of another, as to the circumstance that spectroscopic appliances have on the whole been delicate and expensive physical instruments. Flame spectra may tell the chemist a good deal, but their range is limited, and when it comes to the use of arc spectra and vacuum tube spectra, the observer needs wave-length tables which he may not have in his laboratory. The new chemical spectrometer of Messrs. Adam Hilger, Limited, 75A, Camden-road, N.W., which we illustrate in the sectional diagrams of Figs. 1 to 5, above, combines the advantages of a constant deviation wave-length spectrometer, reading to 1·5 Angström unit, with the compactness, convenience and relatively low cost of an instrument of the microscope type.

The eyepiece E of the telescope T is provided with a slit and a small auto-collimating prism just above it. The light is received by a small mirror which is attached to the eye-piece tube by means of a clamp; these parts (Figs. 4 and 5) will presently be referred to. The rays pass down the tube and through the object glass O to a prism P of 30 deg. The silver backing of this prism sends the rays up again through O and to the eye-piece by means of which the spectrum is observed. The prism is mounted on a table which carries a lever against which a micrometer screw presses (see Fig. 3); the screw rotates the prism and at the same time the drum on which the scale of wave-lengths is engraved. This scale is subdivided by the nine convolutions of a helical groove in which the index moves. By turning the milled head of the drum, one line after another is brought to coincidence and its wave-length determined, the instrument being simply used like a microscope. The cap C which is placed over the prism to exclude extraneous light is shown in its normal position in Fig. 1; it is not removed in ordinary practice.

The reception of the rays emitted by the flame is explained by Figs. 4 and 5. The rays from the source of light fall on the mirror M, which can be turned about its axis and also swung round the axis of the rod R, on which it is adjustably mounted; this rod is held by the clamp Cl, which encircles the upper part of the tube T, and is clamped by means of the screw shown in Fig. 4. The rod R also carries the holder of a diaphragm disc, in the lower portion of which a lens L is inserted; this diaphragm protects the eye from the glare. The rays enter the auto-collimating prism A which is mounted in the upper portion of the tube T, Fig. 1, on the eye-piece side of the slide.

The instrument fits into a wooden case, the outside dimensions of which are 9½ in. by 8 in. by 16½ in. For the study of arc spectra an arc lamp taking 2½ amperes is generally sufficient, and the current may thus be taken directly from any ordinary lighting circuit. When carbon electrodes are used, the lower positive carbon is cored and scooped out to receive the substance; with copper electrodes the few milligrams of the substance required can generally be placed directly on the lower electrode. Both the carbon and the copper electrodes must, of course, be pure. The arc and spark electrodes may also be made directly of the substance to be examined.

NOTES ON NEW BOOKS.

WHEN Professor Carl Benedicks, of Stockholm, delivered the May lecture before the Institute of Metals in 1920, he dealt with the intimate relations between thermal currents and electric currents, and he was able to demonstrate a new effect of this type. Professor Benedicks has communicated his further investigations in this field to the Ingeniörs Vetenskap Akademien, and his English monograph on "*The Homogeneous Electrothermic Effect*," a reprint from No. 5 of the Handlingar, has been published by Messrs. Chapman and Hall, Limited (price 15s. net). Since Seebeck conducted his original research, which covered a variety of phenomena, in 1821, a good many thermo-electric and electrothermic effects have been discovered and rediscovered over again. They are all interconnected; but three main effects may be distinguished, apart from the primary Joule effect, viz., that every conductor is heated by the electric current flowing through it. When the two metals of a heterogeneous circuit, consisting of two different metals in contact, are kept at different temperatures, an electric current is generated (Seebeck). When conversely an electric current is sent through that circuit, the junction is heated or cooled (Peltier, 1834). When the circuit is homogeneous, and consists of one metal only, the temperature of which varies from point to point, however, an electric current is set up by the temperature difference (W. Thomson, 1856). The converse of the Seebeck effect, a generalised Thomson effect, had not been demonstrated, until Benedicks described his new X-effect. He claims to have established a direct "phoretic" transport of heat by the electric current, with or against the current direction, when flowing in a perfectly homogeneous conductor, of the same temperature throughout. The Thomson effect would only be a special case of this new effect. That heat transport would influence the Peltier and Thomson effects as usually measured; it would also play a part in the unipolar conduction of a crystal detector. The effect is

said to be positive in copper and some carbon steels, and negative in constantan; iron seems to be peculiarly sensitive to impurities with respect to this effect. Professor Benedicks has carried out his observations on bars, part of which has been "strangulated," *i.e.*, turned down to a smaller diameter. He made arrangements that the temperature remained perfectly uniform throughout the bar, in spite of the change in dimensions; but could he really do that? Will there not always be some slight want of homogeneity? He explains his observations by suggesting that some metals preferentially take up a positive charge, others a negative charge. The experiments are exceedingly delicate, and so far, we believe, Professor Benedicks stands alone with his X-effect.

Since a good deal of the technical literature of the last few years is admittedly of a quality, not at all commensurate with the price, one is all the more pleasantly surprised occasionally to find a new book, obviously written by a competent and conscientious man, offered at a very reasonable price. "*Die Drahtlose Telegraphie und Telephonie*," of Dr. P. Lertes (Dresden and Leipzig: Theodor Steinkopff; price 3*s.* 11*d.*) is one of these books. If forms Vol. IV of the Wissenschaftliche Forschungsberichte, edited by Dr. R. Liesegang. These reports are compiled especially to enable scientists to pick up lost threads and to acquaint themselves with the advance made during and after the war. Everybody knows that radiotelegraphy and telephony have almost become new sciences in that period, and a glance at the diagrams, the copious literature lists and the index of this volume will convince the reader that Dr. Lertes will help him to understand the astonishing progress achieved. We wonder, however, that Dr. Lertes should speak of "wireless" telegraphy and telephony; radiotelegraphy is the official—and certainly preferable—term, not alone in Germany.

We believe it was Huxley who declared that in order to teach a little science it was necessary to know a great deal. This dictum, which receives periodical confirmation by the amazing incursions into physics of the "scientific correspondent" to a leading newspaper, does not seem to have been sufficiently attended to by Professor J. Arthur Thomson, the editor of "*The Outline of Science*," of which the first volume has just been issued by Messrs. George Newnes, Limited, price 31*s.* 6*d.* net. Professor Thomson is well known as a biologist who thinks, whilst many often appear to be content merely to observe and record. Hence the sections of the volume dealing with natural history and allied questions are well written, accurate and informative. In these latter days when mere wielders of a ready pen presume to lay down the law on important scientific questions, which they all too frequently lack the mental equipment even to understand, it is well that we should have the authoritative and clearly written article on the present position of Darwinism, which is included in the volume under review. There is, in short, no doubt as to the fact of evolution, but much has yet to be learnt as to the factors which have brought it about. It is possible that investigators will in the end have to recognise that the *elan vital* must be included amongst these, but quite properly this element will not be admitted save as a last resort. The position of the biologist and physicist differs in this respect from that of the philosopher. The latter, for example, may hold that mind is involved in all natural phenomena, and that in the ultimate an atom of hydrogen unites with one of chlorine simply because it chooses to do so, but the scientific investigator feels the necessity, so far as may be, of reducing natural phenomena to mechanism as the sole method by which phenomena may be classified and predictions made with safety. Nevertheless, in the ultimate, he would agree with the philosopher that nature is much more than mere mechanism. One of the contributors to the volume under review, in contending for the presence of mind at least in all animate nature observes that, "When a simple one-celled organism explores a corner of the field, seen under a microscope, behaving to all appearance very like a dog scouring a field" . . . "it seems permissible to think of something corresponding to mental endeavour associated with its activity." It is obvious that this writer cannot have seen the extraordinary experiments on surface tension effects shown at the Royal Institution some years ago. A drop of a certain organic fluid was placed on water and divided up spontaneously into little lenticular patches. A drop of a second fluid was then placed on the water, and immediately began to chase and assimilate the small patches of the first fluid. As it reached a patch the pursuing drop sent out a process on each side, which embraced the patch, and having absorbed this into its interior the drop chased another and yet another patch, absorbing each in the same way. When finally gorged, it took up a position in the centre of the water surface. The passage quoted above illustrates the weakness of the book on the physical side, the chapters dealing with physics, while informative in a way, not being of a really reliable quality. Thus the model atom invented and studied by Sir J. J. Thomson did not, as stated, consist of a series of electrons circulating in shells round a nucleus. The conception of the neuclear atom is due to Rutherford. Moreover, it is not true that the nucleus of the atom has been named the proton. The proton is the nucleus of the hydrogen atom and is the unit of positive electricity, and in all other atoms the nucleus comprises several protons and also some negative electrons. In the diagram illustrating the disintegration of radium to its emanation, radium is shown as emitting a β radiation, which is not true. Again the statement on the next page that uranium and radioactivity were not known to Kelvin is, to say the least, misleading. Also in the paragraph on "electrons and light," we have the following: "What is happening is the agitated electrons flying round in their orbits at a speed of billions of times a second make the iron red hot." Now as a matter of fact the hypothesis at present in vogue is that in the mere revolution of an electron round the nucleus no energy is emitted. The writer has apparently failed to grasp the idea that the emission of radiation is due to the sudden fall of an electron from one position of equilibrium to another, the mechanism being essentially the same as the fall of the electrons down the aerial of a wireless station, which gives rise to the loops of electric force which constitute the Hertzian waves.

One cannot be an old member of the British Association without becoming attached to it, and all members, young and old, will be grateful to Sir Charles A. Parsons for suggesting and rendering possible the preparation of a "*British Association Retrospect*, 1831–1921," and to Mr. O. J. R. Howarth, M.A., secretary of the Association, for preparing this very interesting and instructive octavo volume of 318 pages (London: The British Association, Burlington House, W.; price 8*s.*) That the first meeting was held at York on September 26, 1831, was chiefly due to David Brewster and to the Rev. W. V. Harcourt, to Professor J. Phillips and other members of the Yorkshire Philosophical Society, which issued invitations to the Friends of Science. "The return of the sword to the scabbard," Brewster had written, "has been the signal for one universal effort to recruit exhausted resources . . . in this rivalry of skill England alone has hesitated to take a part." There is a very modern ring in the words. Harcourt proposed the name "British Association for the Advancement of Science." Classical scholars, the clergy and some learned societies had held aloof; the *Times* continued to sneer contemptuously for many years, and Charles Dickens indulged in some very cheap punning on the "Mudfog Association for the Advancement of Everything," and on Messrs. Snore, Muddlebranes, Pumpkinskull, &c. By 1833 the Association deliberated in four sections: Mathematics and Physics was the first; Philosophical Instruments and Mechanical Arts the Second; section G, Mechanical Science (later Engineering) was created in 1836. Chemistry (and Mineralogy) had been a section (B) since 1834; the Association did much for the chemists, and the members of the chemical club were, in the sixties known as the B's, or Bees, and were symbolised by bees. The number of sections remained seven from 1836 to 1884; then H, Anthropology, was added, and M, Agriculture finally, in 1912, brought the number up to 13—a number which many members would like to reduce. Women were not admitted till 1843, and the election of a lady as a sectional officer was disapproved of even in 1897, the opposition finally lapsing in 1913. When the Marquis of Breadalbane presided at Glasgow, in 1840, Murchison (then General Secretary) informed Whewell that "he had to prepare a note for the King's Speech." The first meeting outside the United Kingdom, at Montreal in 1884, had strenuously been opposed for a long time. As to the work achieved, Mr. Howarth may well say that "to voluntary service in the interests of science the whole record of the British Association stands as one great memorial."

HERBERT MORRIS, LIMITED.—Messrs. Herbert Morris, Limited, the well-known engineers of Loughborough, have recently issued a small illustrated booklet entirely in Spanish, of their lifting apparatus, conveyors, cranes and boilers. The dimensions are in British and in metrical measurements; in some instances prices are quoted in £. The enterprise of the firm is to be commended and will lead, it is to be hoped, to extensive business with all Spanish speaking nations. Code words of five letters are given in every instance. Speaking from experience we deprecate the use of such short code words, since it frequently occurs that two short code words differ from each other by less than two letters. Even when they differ by two letters, an error in the transmission of a telegram leads to complete uncertainty and requires investigation, hence to delay and expense before an order can be executed.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—One of the best indications of the steady expansion in the engineering branches is to be found in the relighting of six steel furnaces which have stood idle for several months. This step has been rendered necessary to meet the slowly expanding needs of the finished sections, whose stocks of basic materials are exceptionally low. Manufacturers are in the market to cover all new requirements, and are further influenced in favour of placing forward contracts by the fact that prices are not expected to show any further substantial reduction. Steel-makers are pressing for lower coal costs, but colliery representatives point to the high wages charges as compared with competing districts. In addition to the local call, there is a heavy demand on export account for all classes of soft steel. Continental competition appears to be less serious than at any previous period during the last twelve months. For the time being, at any rate, Germany has ceased to be a formidable rival in heavy steel, and there is little evidence of the continuance of Belgian or French underquoting. The rolling mills have not gone back on anything like full-time employment, but are supplying a considerably larger quantity of special materials for the agricultural and automobile industries. Foundries are still badly in need of new orders, but constructional material is more freely on order for home and colonial railways. Japanese inquiries show a distinctly upward movement, especially for circular and cross-cut saws. Business in all qualities of steel scrap is being done at rising rates, stocks having been largely cleared by the recent heavy buying from South Wales and Germany. The position in the lighter section is steadily improving, except in regard to building trade requirements, which are on a low scale owing to the slump in speculative building. The gradual disappearance of low-priced Government stocks is smoothing the way for better conditions in the tool trades. Keen competition among local manufacturers for new business is steadily diminishing, and is giving place to a disposition to quote rates which allow a reasonable margin of profit. Particularly is this the case in the file-making branch, which has experienced a much-needed fillip from the increased activity in the home engineering shops. Quite a nice business is being done with Russia in tools and implements on a cash-with-order basis. Ireland is not altogether a closed market, but the conditions obtaining there inevitably restrict current business to microscopic proportions.

South Yorkshire Coal Trade.—Home industrial concerns adopt a very cautious policy respecting forward commitments. Local collieries protest their inability to grant further concessions on current quotations, but manufacturers are of opinion that the last of the price cuts has not been seen, and that pressure in the right quarters will be productive. Business moves steadily on export account despite crippling freight rates to the coast, and home railways are taking a larger tonnage against new contracts. House coal is difficult to market, with stocks increasing at pits. Recent stocks of furnace coke have been greatly reduced. Quotations:—Best branch hand-picked, 36*s.* to 37*s.*; Barnsley best Silkstone, 33*s.* to 34*s.*; Derbyshire best brights, 27*s.* to 28*s.* 6*d.*; Derbyshire best house, 23*s.* to 25*s.*; Derbyshire best large nuts, 21*s.* to 22*s.*; Derbyshire best small nuts, 16*s.* to 16*s.* 6*d.*; Yorkshire hards, 23*s.* to 24*s.*; Derbyshire hards, 21*s.* to 23*s.*; rough slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; nutty slacks, 7*s.* 6*d.* to 8*s.* 6*d.*; smalls, 3*s.* to 5*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—As was generally expected, Cleveland pig-iron prices are easing. Despite efforts of some makers to keep quotations at the rates until recently officially fixed, business is being put through on lower terms. All quotations are now f.o.t. makers' works or f.o.b. Tees. A drop of 2*s.* in No. 3 G.M.B. Cleveland pig iron can this week be reported, purchasers having been made at 88*s.*, and customers report that they can place repeat orders at that figure. No. 4 foundry is stated to be obtainable at 86*s.*; and No. 4 forge at 84*s.* Some producers, however, refuse to entertain offers at the foregoing quotations. Values of No. 1 and silicious iron are well maintained at 95*s.*, these qualities being still very scarce. Good inquiries on American account continue, but they are mostly for special irons.

Hematite.—Supply of East Coast hematite is quite plentiful notwithstanding curtailed supply by a furnace having been put out of operation because of irregular working. Producers adhere to 94*s.* for Nos. 1, 2 and 3 for home use, and some of them still ask up to that price for shipment abroad, but it is understood that export orders can be placed without difficulty at 91*s.* for mixed Nos. Some buyers indeed express the opinion that purchases for despatch to foreign destinations might be made at less than the figure named.

Foreign Ore.—There is next to nothing doing in foreign ore. Sellers quote best rubio 25*s.* c.i.f. Tees.

Coke.—Durham blast-furnace coke prices are well maintained, sellers continuing to take a firm stand notwithstanding pronounced disinclination of local consumers to pay the rates asked. Medium qualities are 26*s.* 9*d.* to 27*s.* delivered, and several producers will not entertain offers at below the latter figure.

Manufactured Iron and Steel.—Little new is ascertainable concerning finished iron and steel. There is a little more doing in one or two branches, and output is slowly but gradually being increased. A great deal of plant, however, is still idle, and it would seem as though some considerable time must yet elapse before works are once

again anything like normally employed. Keen competition continues for overseas trade, and manufactruers are anxious to book orders for abroad at substantially below the following rates which rule for home business:—Common iron bars, 12*l.*; iron rivets, 12*l.* 17*s.* 6*d.*; steel billets (soft), 7*l.* 15*s.*; steel billets (medium), 8*l.* 5*s.*; steel billets (hard), 8*l.* 15*s.*; steel ship, bridge, and tank plates, 10*l.*; steel boiler plates, 13*l.* 10*s*; steel angles, 9*l.* 10*s*; steel joists, 10*l.* 10*s.*; heavy steel rails, 9*l.* 10*s.*; black sheets, 12*l.*; and corrugated galvanised sheets (24-in. gauge, in bundles), 16*l.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of Trade.—The state of trade in general during the first half of this year has been very unsatisfactory, but the prevailing opinion now is that the worst is past and we can look forward to more, and better, business during the remainder of the year. The labour troubles which lasted so long militated against any improvement in demand, and conditions became so unsettled that much new work has been held up. Whether or not orders for the latter will now be given out remains a matter of conjecture, but there is a more hopeful tone about, and inquiries for steel and iron material have been better of late. The shipbuilding figures for tonnage launched during the past six months and for new vessels under construction show the industry to be in a far from healthy state, but perhaps we may be on the eve of better conditions. Wages have certainly come down, and so also has the cost of living, but both have yet to fall a bit furtner before business can be expected to expand on a generous scale. New vessels are still too dear from the point of view of the shipowner, and until the cost of construction comes down further—consequent upon a decline in the price of steel and iron—few new contracts are likely to be given out. The general trade of the country would look to be a shade better, and as soon as business settles down after the holiday season, a gradual improvement all round is anticipated.

Scottish Steel Trade.—With all the steel works closed down for holidays this week, there is little fresh to report. As orders have been so scarce of late, and the tonnage now on the books is so small, the stoppage will be much longer than usual at this time, and it will be the beginning of August before work generally is resumed. There are a fair number of inquiries in the market at present, and sellers are hopeful of fixing up some of these, but it is doubtful if buyers will do much business until prices are more favourable. Quotations show no change over the week.

Malleable Iron Trade.—There was no rush to secure delivery of orders on hand for bar iron before the closing down for the holidays, and makers in the West of Scotland have not a great amount of work to commence with when they resume operations. That state is rather disappointing, as it was expected that the recent decline in prices would have improved the conditions at the different works. With "crown" bars at 10*l.* 10*s.* per ton, delivered Glasgow, consumers are very slow to purchase supplies beyond actual requirements, as they anticipate doing better in the near future, but from the producers' point of view the present costs do not warrant even as low a figure as now exists.

Scottish Pig-Iron Trade.—The Scottish pig-iron works were rather better off for business before closing last week, but all the same, the amount of work booked is not very heavy. Foundry iron has been in slightly better demand, but hematite is the subject of poor inquiry. Export inquiries are fairly good, and the outlook in that direction is very hopeful.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—At last the British coal trade, and particularly South Wales, is receiving a direct benefit from the strike of miners in the United States. Orders have been placed for about 70,000 tons of Welsh coal and 100,000 tons of north-country coals, and already several steamers have been chartered to carry the coal to New York, Boston or Philadelphia at rates varying from 7*s.* 6*d.* to 8*s.*, free delivery. So far as South Wales is concerned, the orders have come at an opportune time, for numerous collieries are working short time, and a number are completely on stop in consequence of the lack of trade. So far the American demand has had little effect on prices, though it has caused salesmen to stiffen their ideas for forward business and to arrest the downward tendency in values for prompt loading. Best Admiralty large is still round 24*s.* 6*d.*, and best steam smalls 17*s.* It is, however, interesting to note that a contract for 50,000 tons of best Admiralty large coal for delivery over the last five months of this year has been placed at 24*s.* for 10,000 tons delivery in August, and 24*s.* 9*d.* for the 40,000 tons to be shipped in the last four months. The great change that has taken place in the f.o.b. price of export coals will be realised when it is mentioned that in the first and second quarter of 1914 it averaged 15*s.* 5½*d.* per ton, which was increased to 72*s.* 3½*d.* in the first quarter of 1920, and to 80*s.* 5½*d.* in the second quarter, and then dropped to 23*s.* 11*d.* in the first three months of this year, and appreciated to 24*s.* 10½*d.* in the June quarter of this year. In June, 1,970,204 tons of coal were exported abroad from the principal South Wales ports, which was 242,964 tons less than in May, while the value of the June shipments at 2,453,363*l.* showed a reduction of 341,240*l.* Shipments of large steam coal amounted to 1,203,169 at an average price of 26*s.* 5*d.* per ton, or 5*d.* less than in May, and steam smalls, 518,930 tons, at an average price of 18*s.*, a fall of 7*d.* per ton. Steam smalls shipped from Cardiff averaged 17*s.* 8*d.* per ton, a drop of 10*d.*; large, 26*s.* 9*d.*, a fall of 3*d.*; and throughs, 22*s.* 8*d.*, an increase of 9*d.* Steam smalls shipped from Swansea averaged 16*s.* 10*d.*, a reduction of 2*s.* 2*d.*; throughs, 19*s.* 6*d.*, a fall of 1*d.*; and large, 25*s.* 9*d.*, a drop of 5*d.* Anthracite small exported from Swansea, averaged 28*s.* 10*d.*, a rise of 4*s.* 9*d.*, and large 41*s.* 9*d.*, an increase of 4*s.* 4*d.* per ton.

Another Shipping Crash.—Another of the Cardiff shipping companies has failed to weather the slump. The directors of the St. David's Steam Navigation Company, Limited, which was formed in 1919, has informed the shareholders that "owing to the continued depression in the freight market, the bankers gave the directors notice that they could not allow the company to keep on trading at a loss, thus increasing the bank overdraft, and gave instructions for the immediate disposal of the boats; consequently this was done, and the steamers have not been trading on the company's account as and from the 10th January, 1922." The issued capital of the company was 155,665*l.*, and the bank overdraft 392,554*l.* A loss on trading of 48,837*l.* was sustained in the year ending January 10 last. The company owned four steamers, aggregating 23,700 tons deadweight, which were shown in the balance-sheet at 616,836*l.*

The Iron and Steel Trades.—Prices for Welsh tinplates show a firmer tendency owing to the fact that order books for the next quarter are fairly well filled. Current prices are from 19*s.* 6*d.* to 19*s.* 9*d.* per box. Exports of iron and steel goods in the past week amounted to 7,966 tons, compared with 11,455 tons in the previous six days. Of the total, 5,476 tons were tinplates, 1,765 tons blackplates, 655 tons iron and steel, and 70 tons galvanised sheets.

TRANSACTIONS OF THE INSTITUTION OF GAS ENGINEERS.—The volume of the Transactions of this Institution, recently issued, for the session 1920–21, covers the joint meeting with the Institution of Electrical Engineers on June 16, 1920, at which meeting a paper previously read by Sir Dugald Clerk at the Royal Society of Arts, on "The Thermal Efficiency of the Generation and Use of Gas and Electricity," was jointly discussed, together with the Report on the "Coal Gas and Electrical Supply Industries of the United Kingdom," by Sir Dugald Clerk, Professor A. Smithells and Professor J. Cobb. We referred to this meeting on page 863 of our 109th volume. The Transactions also deal with the annual general meeting held in London in October of last year and reported in our last volume on pages 546 and 560. The presidential address, delivered by Mr. T. Goulden, and the reports and papers presented at this meeting, are printed in full, together with the discussions, the material occupying nearly 700 pages. The Transactions are published for the Institution by Messrs. E. and F. N. Spon, Limited, 57, Haymarket, London, S.W. 1.

NORWEGIAN COAL MINING IN SPITZBERGEN.—The Norwegian Government have introduced a proposal to the effect that the Norwegian coal mining industry in Spitzbergen should be discontinued for a year. There are altogether four Norwegian companies engaged in coal mining in Spitzbergen and Bear Island, and the State has hitherto lent them an aggregate of 12,800,000 kroner. One of the companies has recently gone bankrupt, and the other three are in need of capital to enable them to carry on, but the Government evidently think that they have gone far enough. That, however, is not the opinion in Norway outside the Government. The Press is entirely against abandoning the Norwegian interests in Spitzbergen; a number of scientists have appealed to the Storting in the same cause, and a great many industrial concerns have also protested. Should the Government carry their point the mines will either be allowed to fall into disuse and probably never be started again, or they will have to be sold, which, of course, would put an end to Norway's interest in Spitzbergen. The reason of the critical position is partly very high cost of installation and partly the heavy fall in the price of coal. It is, however, confidently anticipated that, with rational working, these mines could supply the whole of Norway's coal requirements.

BRITISH INDUSTRY AND FINANCIAL ASSISTANCE TO GERMANY.—The following resolution passed by the executive committee of the Federation of British Industries at its meeting in London on the 12th inst., was forwarded to the Prime Minister by Colonel O. C. Armstrong, D.S.O., the President of the Federation:—"In view of the present position respecting the questions of reparations and German exchange, the Federation of British Industries desires to reiterate the request submitted to the Prime Minister on December 19, 1921, that H.M. Government should not commit themselves to any step for modification or revision of the existing arrangements until industry, which is more vitally affected than any other section of the community by the reactions of these problems upon the world's economic system, has been given an opportunity of expressing its views. The Federation is especially concerned that the credit of the country shall not be definitely pledged for the purpose of rendering financial assistance to Germany until such consultation shall have taken place." We entirely approve of this resolution, although we are not specially posted in regard to "Industry's views." We are firmly of opinion that the situation in Germany, as a whole, is far better than is made out, also that Germany will continue doing everything in her power to elude her obligations as far as possible.

NOTICES OF MEETINGS.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Southern District Meeting. Saturday, July 22, at 10.30 a.m., in the Assembly Room, Town Hall, Basingstoke. The following papers will be read and discussed: "Basingstoke: Its Municipal Estates and Municipal Undertakings," by J. H. Drew, M.Inst.C.E. "Basingstoke Electricity Works," by F. Swarbrick, A.M.Inst.E.E., A.M.I.Mech.E. Visits to Works.

THE ROYAL METEOROLOGICAL SOCIETY.—Monday, July 24, at 3 p.m., at the Royal Society's Rooms, 22, George-street, Edinburgh. The following papers will be read: (1) "Observations of Upper Cloud Drift as an Aid to Research and to Weather Forecasting," by C. K. M. Douglas, B.A.; (2) "Note on the Effect of a Coast Line on Precipitation," by J. S. Dines, M.A.; (3) "Note on Turbulence," by Dr. A. E. M. Geddes and G. A. Clarke. Exhibition of meteorological instruments.

THE STRUCTURE OF COKE.—Though opinions differ as to the precise mode of formation of coke, it is agreed that some of the constituents of a coking coal fuse when the coal is heated in the retort, and gas is cooled by the decomposition of these or other constituents, and it is owing to their partial escape that coke has a porous cell-structure. In a paper read before the Leeds Section of the Society of Chemical Industry (Journal of the Society, June 15), Professors H. D. Greenwood and J. W. Cobb describe some experiments with a Nottingham gas coal (percentages: carbon 77·4, hydrogen 5·7, sulphur 1·8, nitrogen 1·3, oxygen 10·2, ash 3·8, volatile matter 37·3), coked at three different temperatures, viz., 550 deg., 850 deg. and 1,100 deg. C., and parallel experiments with a hard by-product coke from an Otto battery. It was found that the first stage in the coking process, up to 550 deg. C., is constituted by the cell formation; the cells then have relatively thick walls of low specific gravity; owing to the swelling of the mass during this period it is difficult to withdraw coke at low temperatures from the retorts or gas producers, particularly when they are fitted with bells. At higher temperatures, up to 850 deg. C., the whole mass shrank and became denser; the coke then had its maximum porosity and the cell walls were thin. In the last stage the mass further contracted, but the specific gravity did not change, because the cell walls which became thicker had a higher density than the original coal, and the porosity went down; the coke produced was very strong. The density changes of the coke ranged from 1·59 to 1·88; the density therefore did not approach the density of graphite, 2·3, at any stage. Since the mineral constituents present in the coal would raise the density, whilst coke conducts the electric current as if it were partly graphitised, this would indicate, as Mr. Hodsman pointed out during the discussion, that the coked coal still consists of complex hydrocarbons and not of carbon alone. Another point mentioned during the discussion, by Mr. W. McD. Mackey, was that coking coal deteriorates when kept for weeks after leaving the face.

IRON ORE IN THE MALAY PENINSULA.—The following paragraphs appear in the annual report of Mr. J. B. Scrivenor, Government Geologist, Federated Malay States: Interest has been shown in the iron ore deposits of the Peninsula, following on the exploitation of a deposit on the Batu Pahat River, Johore, by a Japanese company (Nanyo Kogyo Koshi). This deposit was visited by the Geologist in January on behalf of the Johore Government. The workings are on Bukit Menia. The backbone of the hill is a lode of hematite, with a little other mineral matter, trending 170 deg. to 350 deg. The slopes on either side are covered with débris from the lodes which is stated to be between 10 chains and 15 chains broad, and 40 chains long; but no walls were visible in January. Evidence was found of granitic rocks in the neighbourhood of the lode, a boulder at the foot of the hill and kaolin in a well. The ore is being exported to Japan. A large hematite deposit occurs at the north end of Gunong Panjang, close to the high road from Ipoh to Tambun. This is on a rubber estate. Attention was drawn to its size by Mr. J. F. Newsom, of the Yukon Gold Company, and late of the United States Geological Survey. Mr. W. E. Cameron reported that there are possibly some 2,000,000 tons of ore available above surface drainage level and probably 4½ additional million tons within 100 ft. below that level. Analyses by Mr. J. C. Shenton of two samples of the ore collected by Mr. Cameron are as follows:—

	Per cent.	Per cent.
Iron	68·02	68·70
Sulphur	0·03	0·013
Phosphorus	0·07	0·086
Manganese	0·60	0·45
Ferric oxide	97·12	98·14
Insoluble matter	1·08	0·87
Phosphoric anhydride ...	0·17	0·197
Sulphuric anhydride ...	0·10	0·034
Manganous oxide	0·66	0·50
Lime	trace	trace
Magnesia	trace	trace
HO_2 and loss on ignition...	1·48	0·38
	100·61	100·121

Unfortunately this deposit is badly situated for transport. To work it on the spot would entail the destruction of a large area of jungle in the main range for charcoal even if electric furnaces were used for smelting.

SOCIÉTÉ DES CHANTIERS ET ATELIERS DE LA GIRONDE: HARFLEUR YARD.

(*For Description, see Page* 72.)

FIG. 4. VIEW IN THE PLATE AND SECTION SHOP.

FIG. 5. VIEW IN THE PLATE AND SECTION SHOP.

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ENGINEERING.

FRIDAY, JULY 21, 1922.

FACTORIES AND WORKSHOPS.

STATISTICS are tiresome to compile, difficult to interpret, and far from entertaining to peruse. Their value is, however, indisputable, even although the statist can deal merely with quantities, and has to ignore all qualitative considerations, which are often far more important, than the question of how much more or how much less, which is all that his elaborate tables are able to show. One of the good features of the Annual Report to the Home Office on Factories and Workshops is that the statistical matter is supplemented by an interesting commentary on the true import and bearing of the tabulated figures, from which the ill-informed reader might otherwise draw very erroneous conclusions. From the report* for last year, just published, it appears that the total number of factory and workshop accidents in 1921 was 92,565, of which 951 proved fatal, whilst the corresponding figures for the preceding year were 138,702 and 1,404 respectively. At first sight, the reduction appears gratifying, but the main reason for the diminution was the falling-off in trade. This was largely due to the unwarranted action of extreme pitmen, who having done their worst to destroy our industries by their intemperate demands and by an unreasonable strike, are now appealing for sympathy because the consequent slackness of trade has recoiled with disastrous results on themselves. This is a course of events which, as previous experience shows, might have been confidently anticipated; but certain sections of the labouring classes seem to be quite unable to appreciate the lessons of history.

Though, as pointed out above, the casualty figures for 1921 are not properly comparable with those of the preceding year, it is nevertheless a fair deduction from other matter in the report that industrial conditions are being steadily ameliorated. The frequent assertion of labour leaders that the workman of to-day is worse off than his predecessor of the last century finds no support in this official report, where it is definitely and distinctly affirmed that "the status of the average workman is being steadily raised." The many "occupiers" who comply only with the minimum demands of the Home Office have their counterpart in the many workmen who misuse the provision made. Nevertheless, there is a steady increase in the number of cases in which the contribution made to the welfare of those employed is far in excess of official requirements. The improvement in the average conditions is best brought out by a consideration of the change both in action and outlook which has been effected during a fairly long term of years. Trade conditions and the like may cause temporary set-backs, and those who concentrate their attention on the immediate present may well fail to recognise that though an individual wave may be momentarily retrogressing, the tide of improvement rolls steadily onwards. In 1914, the number of factories with welfare schemes in operation were comparatively few; but to-day, reports from all over the country bear evidence of the enormous progress made. It appears, however, as would be anticipated from experience in other matters, that success nearly always depends on some individual personality. Where personal enthusiasm is lacking, and the mere letter of the law attended to, the result, it is stated, is such as to "seem hardly worth doing at all."

Certain curious difficulties have arisen in connection with mess rooms. The Act requires that all "protected persons" shall have the same meal times. This implies overcrowding of the dining-room and a great increase in the cost of making provision for those who wish to use it. A little elasticity in the hours worked in different sections of a factory would often prove of very material advantage. The growing popularity of these mess-rooms is well shown by one case recorded. Here, in new works laid out for about 2,000 men, the mess-room was designed to seat 1,000, but actually accommodation has had to be found for 1,500. In certain cases, social distinctions have occasioned trouble, as some grades of the workmen object to take their meals at the same table as those whom they regard as their social inferiors.

It is disappointing to learn that the movement for works safety committees makes way but slowly, the inertia of the men workers being particularly marked. Nevertheless, progress is being made and successful instances are reported from every industrial area.

Sanitary reform also makes way at a pace which is discreditably and disappointingly slow. Outside of the London area the sanitary accommodation provided for the workmen is too frequently of a disgusting character, and the local authorities have been very slow to take action. In certain cases it may, no doubt, be impracticable to connect up a factory with a public sewerage system, but, as one of the inspectors points out, this does not make it impossible to instal water closets.

The 48-hour week is stated to be now almost universal. Owing to slack trade, employers have little reason for soliciting longer hours, and should such a demand arise, it would meet with more determined opposition from organised labour than a proposal to reduce wages. No doubt, labour organisers have strong personal reasons for desiring a short working day, and it would be interesting to know how far their views are shared by the rank and file. When the 54-hour week was in vogue, we have known a workman, though strongly opposed to strikes, declare that he would resist to the utmost any attempt to re-introduce the old 10-hour day. On the other hand, some of the older workmen, accustomed to the 54-hour *regime*, are frankly bored with the additional free time at their disposal since the introduction of the present short working week.

In the mining industry a ten-day fortnight has long been an established practice, and it appears that the custom is now spreading to other industries. Thus, in the Finsbury district it is stated that fully one-half the factories do not open on Saturdays. In other areas foundries also close on that day, as with the very short hours available it is considered unprofitable to start the cupola. The movement may, in many cases, have started as a convenient way of working short time, pending an improvement in trade, but cases are quoted in which, on a return to full time, the practice has been continued, two extra hours being worked instead on Thursday and Friday evenings. The one break day is now common, save in factories where there is exposure

* *Annual Report of the Chief Inspector of Factories and Workshops for the Year* 1921. [Cmd. 1705.] H.M. Stationery Office. 1922. [Price 3*s.* net.]

to great heat. In some cases it has been found advantageous to have a 10 to 15-minute spell in the middle of the longer section of the one-break day.

In a previous report it was stated that one effect of high wages had been to lead many small employers to dismiss their hands and to accept only work they could carry through themselves, or with the aid of one or two of their best men, whom they took into partnership. Another effect is noted in the present report, where the high wage rate is stated to have caused a sensible reduction in the number of "young persons" employed, and also to have led to an increase in the number entering blind-alley occupations in preference to accepting the lower wages necessarily associated with apprenticeship to a trade. In the London area, the continuation class requirements have also tended to discourage the employment of these "young persons." The two-shift system is being adopted in certain cases, with considerable advantage. In fact, lacking this resource, certain trades would have been abandoned in the face of foreign competition, and of the difficulty and cost of acquiring the extra machinery which would have been necessary were the same output achieved in a single shift. Of course, difficulties do arise where two workers operate the same machine, which is likely to be badly maintained unless special steps are taken to ensure that it receives fair treatment. A still greater difficulty is the additional strain which the two-shift system imposes on the management.

The trade conditions have not been favourable to enterprise, nevertheless some important new developments are noted in the report. Mention is made of a new type of gas-producer installed in a Swansea steel works. This is credited with an output four times that of the type previously employed, and is said to be operated with much less labour. In other cases, slack trade has provided the opportunity for overhauling plant and machinery and buildings, which perforce received during the war less care than customary. In general, however, there has been a curtailment of all avoidable expenditure. Indeed, some occupiers, being unable to pay their rents, are reported as being reluctant to demand from their landlords the execution of highly necessary repairs. Many, no doubt, will go permanently out of business. From one point of view, this will be an advantage, as it is the small proprietor and occupier, and not the "bloated capitalist" and "soulless corporation" who is most careless of men's lives and well-being, and causes the most trouble to the factory inspector.

High wages promote the substitution of mechanical power for muscle power, a change which would not have commended itself to Ruskin. In some of the "gorgeous nonsense" for which that author was responsible, he advocated the harnessing of men to canal barges, for which he could have found a precedent in the way Swift's Houyhnhnms made use of the Yahoos. Those who realise that man's glory lies in his mind and not in his muscles, will, however, continue to resent the doing by human muscle of what can be equally or better done by intelligently-designed machinery. When Fairbairn and his partner started "on their own," their lathe was driven by a big Irish labourer. Such misapplications of human powers have almost disappeared from engineering workshops; but have been largely retained in the potteries, where women and girls are much employed as wheel turners and lathe treaders. It is accordingly gratifying to note, that a power lathe is now being applied to china turning, and it may be hoped will ultimately render lathe treading unnecessary.

In further reference to the pottery trades, it is interesting to note that leadless glazes are being abandoned and replaced by low-solubility glazes which make the desired high finish more easily attainable. Of course, this will necessitate precautions against lead poisoning. The danger of this form of poisoning has made an unexpected appearance in certain other trades. Thus, there have been several cases in which the sufferers have been men using the acetylene torch for cutting up old ships' plates. During the operation, the lead in the paint was driven off by the heat and was absorbed by the workmen. In another case in which galvanised plates were being cut up by the torch, the workmen suffered from "brass founder's ague," due to the zinc fumes. Several reported cases of lead poisoning in printing works turn out to have been wrongly diagnosed. An important departure in the dangerous trade of white lead manufacture is recorded in the report, which states that in a new Cheshire factory the whole of the operations of washing, grinding and packing are being effected mechanically.

Another trade in which mechanical operations are being increasingly effected by machinery in place of, as hitherto, by "hand," is the glass trade. The report comments upon the small numbers employed in this important industry, a condition of affairs which is attributed to the higher artistic skill of foreign competitors, and to cheap labour abroad. The cause first suggested is however non-existent, as is easily seen by comparing the designs of artistic glassware of home and foreign origin, as illustrated in the 10th edition of the *Encyclopædia Britannica*. Here the superior taste of the British product is made strikingly evident. There has, however, been another factor involved, of which no mention is made in the report, viz., the resistance of organised labour to improvements in methods of working. Thus, the use of the modern gas-fired furnace was barred for years by the glass workers' union, an action which was equivalent to a substantial bounty on the foreign-made article.

The report records much progress in the safe-guarding of machinery, and also points out that the majority of such accidents as do occur cannot be attributed to neglect in this regard. Of course, with many machines, it is difficult to protect the worker, without at the same time hampering his activities, but a steady advance in the solution of these difficult problems is being maintained. One important firm engaged in press work has attained such a standard of protection, that no accident occurred during the past year. Abrasive wheels are nearly as difficult to protect as presses, and the guards provided are often lacking in strength. The report states that cast-iron guards should not be used for roughing wheels over 8-in. in diameter, nor for wheels used for precision grinding if over 12-in. in diameter, but malleable castings may be used for "precision" wheels up to 20-in. in diameter. To diminish the danger of bursting, surface speeds should not, in the case of grindstones, exceed 4,000 ft. a minute. In a previous report, however, it was stated that large wheels should not be run at as high speeds as smaller ones. Another danger associated with grinding is the inhalation of silica dust. From the report it would appear that with other abrasives no similar danger arises, but a clearer and more definite statement on this important point is highly desirable.

As usual, there were many accidents with cranes and hoists. A common cause is the falling of a load from its slings. The failure of chains or hooks was responsible for less than 5 per cent. of the total casualties; which is somewhat remarkable in view of the very severe service exacted and the liability to overload. Some firms are attaching the hook to the chain through the medium of a volute spring, an arrangement which must greatly diminish the intensity of shocks. The practice of insuring cranes is extending, and as this involves periodical inspection of the crane by an expert, failures due to faulty material should be eliminated. Wire rope slings are said to be preferable to chain slings, as the wire rope shows wear long before it ceases to be safe. On the other hand, the use of wire ropes introduces another danger, as there have been several cases of injury to an attendant's hands by broken wires.

THE WORLD'S MERCHANT SHIPPING.

IT is a rather remarkable circumstance that of all the principal maritime nations of the world, the United Kingdom is the only one of which the merchant tonnage owned has diminished during the past year. If we consider only steamers and motor vessels of steel and iron construction, as being the class of shipping of most economic importance at the present time, it appears, from the 1922–23 edition of Lloyd's Register just issued, that the tonnage of the British merchant fleet is actually less now than it was a year ago by some 235,000 tons, the difference being probably due to the fact that a large amount of tonnage has been sold to foreign owners during the year. The tonnage of the class of shipping above referred to now owned in this country amounts to 19,053,000, which is only 176,000 tons higher than the corresponding figure for June, 1914, and is less than that for this time last year by the figure previously given.

We do not, however, take a pessimistic view of the situation, because there is no doubt that the ships built in the near future will be much more economically operated than the old ships now disposed of. The opportunity will arise, we hope at an early date, for the construction of such new ships, especially in view of the reduction in wages and the improved organisation of the shipbuilders and marine engineers, making possible the quotation of lower rates per ton. In this event our shipowners will be in a much better position than even before the war to compete for the world's carrying trade.

The British merchant fleet, however, is still larger than that of any other nation, although our lead in this respect is much less than was formerly the case. In June, 1914, we owned 18,877,000 tons of merchant shipping, which represented over 44 per cent. of the world's total at that time, viz., 42,514,000 tons, and our nearest rival, Germany, owned 5,098,000 tons, or 12 per cent. of the total. The second place is now taken by the United States, the sea-going merchant fleet of which country amounts to 12,506,000 tons, or 22 per cent., while the present British tonnage represents only 33¼ per cent. of the total, which now stands at 56,802,000 tons.

Many of the Continental nations, on the other hand, have materially increased their merchant fleets during the past year, the most notable example being Germany. The tonnage of German merchant shipping now stands at 1,783,000 as compared with 654,000 tons a year ago, the addition of 1,129,000 tons being accounted for partly by new construction and partly by the transfer back to the German flag of ex-German vessels which had been allocated or sold to other countries. This fact, taken in conjunction with the activity in German shipyards, to which reference was made on page 48 *ante*, would indicate that our late enemies are making strenuous efforts to recover their pre-war position in shipping; at present they take ninth place in order of tonnage of merchant shipping owned.

Japan now possesses the third largest merchant fleet, the tonnage owned in that country being 3,325,000, or nearly double the pre-war figure, while France follows closely with a merchant tonnage of 3,303,000, which is only 22,000 tons less than that of Japan. Considerable additions have been made to the Dutch merchant tonnage during the year, the figure now standing at 2,613,000 tons, as compared with 2,207,000 tons a year ago. The positions of the other principal ship-owning countries are as follows: Italy, 2,600,000 tons; Norway, 2,337,000 tons; British Dominions, 2,201,000 tons; Spain, 1,187,000 tons; Sweden, 996,000 tons; and Denmark, 944,000 tons.

An important point which must be borne in mind in comparing the efficiencies of the different merchant fleets is the variation in the proportion of comparatively new vessels, due to the large amount of tonnage built by some countries during and since the war. For instance, of the sea-going vessels owned in the United States, nearly 63 per cent. are less than five years old, whereas the proportion in the case of the United Kingdom is less than 23 per cent. In Japan the proportion of new vessels is 40 per cent., and in France, Holland, Germany, Belgium and Denmark, the percentage ranges from 30 to 33⅓. The importance of this point is due, of course, to the fact that considerable improvements in methods of propulsion have been made in recent years, so that, in general, the newer vessels should be more economical in operation than the older ones. In this connection it may be interesting to add that of the vessels of 15,000 tons and over, of which 76 are owned by the various countries of the world, 33 are less than five years old, 18 are between five and ten years old, and the remainder between 10 and 25 years old.

The increasing importance of tanker tonnage, to which reference was made in the previous article

above referred to, is very clearly shown by a comparison of the latest Register Book with that for 1914. At that time, there were in existence 385 steamers, totalling 1,479,000 tons, for the carriage of petroleum in bulk, whereas to-day there are 977 steamers and motor vessels, making 5,057,000 tons, engaged in the same trade. The proportion has thus increased from 3½ per cent. to nearly 9 per cent., and that this proportion is still increasing will be evident from the fact mentioned in our previous article that the tanker tonnage now building is over 16 per cent. of the shipbuilding work in hand. The average size of the tankers now in use, omitting those of less than 2,000 tons, which are mainly used for local trade, works out at 5,973 tons, but there are 353 vessels of this class of between 6,000 tons and 10,000 tons each, and 43 of over 10,000 tons.

Doubtless the increase in tanker tonnage has been affected by the development of oil fuel for marine propulsion. There are now 2,793 steamers with a total tonnage of 14,383,000, fitted for burning oil fuel under boilers, as compared with 364 vessels of 1,310,000 tons, so fitted in 1914; the proportion of oil-fired tonnage has thus increased from 2·62 per cent. to 22·34 per cent. during the last eight years. In the same period the number of vessels propelled by internal-combustion engines has risen from 290 to 1,639, and the tonnage from 234,000 to 1,511,000, the latter figure including 149 vessels of over 3,000 tons each. The tonnage of motor ships is now 2·35 per cent. of the total, the proportion being exactly five times as great as in 1914. The proportion of tonnage entirely dependent on sails for propulsion, on the other hand, has diminished from nearly 8 per cent. in 1914, to 4·7 per cent. at the present time, a fact which clearly indicates the low economic value of this class of shipping.

If space permitted, many other useful and interesting deductions could doubtless be made from a careful analysis of the data included in the Register Book, but those given above will serve to show the trend of development in merchant shipping. They also indicate very clearly that international competition for the world's carrying trade will be keener in the future than was formerly the case.

NOTES.

British Engineers in the Argentine.

The need commonly felt by British engineers engaged in professional work abroad for some central meeting place at which the problems arising in the course of their duties can be discussed, has led in many cases to the formation of overseas branches of the parent British institutions or of separate local societies. Such organisations, if properly conducted, cannot fail to be of service both from the technical and social standpoints, especially to the younger members of the profession, and their formation should, therefore, be encouraged wherever the conditions render this possible. In the Argentine, where a large number of British engineers are now engaged in railway and electrical work, the necessity for some organisation to promote intercourse between members of the profession has long been felt, and has recently led to the formation of a body known as the Association of British Engineers in the Argentine Republic, with headquarters at Calle Lavalle 349, Buenos Aires. The main objects, indicated above, will be achieved by the formation and circulation of a register of members, the provision of a meeting place and technical library, the holding of meetings for the reading and discussion of papers, and the arranging of visits to works, etc. Special attention will also be given to the interests of the younger members by assisting them to extend their experience and to obtain suitable employment. Full membership will be confined to corporate members of a British engineering institution to which admission is obtained by examinations, or to persons who can otherwise satisfy the Council that they have attained a certain standard of eminence in the profession. Associate members, junior members and associates, however, are also admitted, but, in general, British nationality or parentage is an essential condition to membership in any grade. The list of members, a copy of which we have received, already contains the names of over 200 members and associate members, as well as of a number of junior members and associates. The President for the current year is Mr. Leonard Cooper, and the Hon. Secretary, Mr. John H. Taylor; the majority of the officers, we notice, are either members or associate members of the more important technical institutions in this country. We should also mention that British engineers are invited to make themselves known to the Secretary when visiting the Argentine, as the Association offers them any assistance in its power.

The British Empire Exhibition.

Rapid progress has been made with the work of construction on the site of the British Empire Exhibition since the first sod was turned in January last by H.R.H. the Duke of York. The site has a total area of about 130 acres, and is situated between Wembley Park station on the Metropolitan Railway and Wembley-hill station on the Great Central line. The objects of the exhibition, which will be open from April to October of 1924, are to further the development and utilisation of the raw materials of the Empire, to foster inter-Imperial trade, and to make the public of this country better acquainted with the resources of the Overseas Dominions. As is now generally known, the British Engineers' Association has undertaken the organisation of the whole of the shipbuilding, engineering and machinery section of the exhibition, and on Thursday, the 13th inst., the President of that body, Mr. Nevile Gwynne, together with the council and a number of members and other prospective exhibitors, paid a visit to the site in order to see the state of progress. The great sports stadium, which will provide seating accommodation for 35,000 persons, and will be ready for use in April of next year, is already well advanced. So far, some 50,000 cub. yards of earth have been excavated from the stadium site by means of a Bucyrus drag-line excavating machine, the earth being deposited outside the area in the form of a bank. The excavation of the central part is still in progress, but the foundations and columns have been in position for some time, and the stands are now in course of erection. The foundations for the two main buildings to accommodate the industrial exhibits of the United Kingdom have been placed, and the work on the superstructure commenced. One of these buildings, which are situated near the entrance from Wembley Park station, will be used to house the engineering and machinery exhibits. Both will be divided into open galleries 75 ft. and 50 ft. in width, with arched roofs of reinforced concrete, and the height will vary from 30 ft. to 50 ft. Railway tracks of standard gauge will run through the buildings in the machinery section, which alone covers about 4 acres, and 25-ton overhead travelling cranes will be provided for handling the exhibits. Other buildings are to be erected for the accommodation of the exhibits of the Dominions and India. Most of the buildings will be of a permanent character, it being intended to maintain Wembley Park as an exhibition and athletic centre after the conclusion of the British Empire Exhibition. The British Engineers' Association, we believe, are using every endeavour to make the engineering and shipbuilding exhibits thoroughly representative of the best modern practice, and we trust that they will be accorded the full support necessary to attain this object, not only by members of the association but by the industries in general. Mr. H. R. Summers is Secretary of the Association, and the offices are at 32, Victoria-street, Westminster, S.W.1.

The British Cast Iron Research Association.—The Association state that their research work in connection with draws and shrinkages, moulding sands and refractories, internal combustion engine cylinder castings, and methods of testing cast iron, are being pushed forward, and very valuable data collected. A Special Committee has been appointed to carry out a thorough investigation in connection with malleable iron castings with the view of broadening out the use of this class of casting. The first bulletin giving full details of the researches already carried out is now being issued to the members, and subsequent issues will be made as the work progresses. The research on refractories which is being carried out in conjunction with the British Refractories Research Association will include blast-furnace linings. The membership of the Association is increasing and foundries are taking a keen interest in the work, which has already proved to be of much valuable assistance to members.

CHOICE OF A SYSTEM FOR ELECTRIC TRACTION ON MAIN LINE RAILWAYS.

By L. Thormann, Consulting Engineer to the Bernese Subsidised Railways.

(*Concluded from page* 36.)

Generation and Transmission.—With continuous-current traction no doubt exists about the form in which the energy would be generated, for the three-phase system at standard frequency alone comes into question. Similarly the same system would be used for transmission. The solution of the problem for single-phase traction is less simple. It has been seen that the smallest loss and the lowest costs are obtained when the traction current is generated in the form in which it is used for shorter distances up to a radius of 50 km. to 60 km. at the pressure of the overhead conductor, and for longer distances with a higher transmission pressure. This solution would be adopted where the generating station is to be built, if not exclusively, at least chiefly for traction. If the station, in addition, has to supply power to a general three-phase network, it would pay to install generator sets of both kinds wherever the amounts of energy are of such magnitude as to demand separate units and transmission lines. This condition would mostly occur when a unified main line network had to be electrified for locomotives of 2,000 h.p. to 3,000 h.p. Such networks demand powers of 20,000 kw. and upwards, and thus need several transmission lines, which for reasons of safety cannot be joined in parallel. Similarly, separate machine units are necessary for generating the power. Consequently it is not absolutely necessary to have a uniform system of generation; indeed, it is preferable to work in groups, because eventual troubles then affect smaller areas, while the energy liberated on short-circuits is relatively smaller and therefore easier to deal with, than when all the energy sources are joined in parallel.

It is only necessary to mention the difficulties of pressure regulation which are met with when a railway with its rapidly fluctuating load has to work in parallel with a lighting and power network.

In large stations it is easy to divide into groups for the two services. An equalisation of the load conditions of the two services to utilise the machinery to the best advantage can be obtained by means of reserve sets having a generator for each system coupled to the same prime mover, or by installing reversible motor generators. Such reserve sets, which would only be used exceptionally, will affect the capital costs less than the alternative of generating on one system only and converting power for the other system. Uniform generation is preferable, however, in small stations, where there are only a few units, or where one system is relatively unimportant. The same transmission poles can be used equally well for carrying the lines of different systems as for lines of the same system. Thus a uniform system for generation and transmission must be regarded as a theoretical desideratum, but no regret need be felt where this is not feasible.

Interference with Communication Circuits.—In discussing the question of electric traction systems, it is important to consider the effects of the railway power currents on the neighbouring communication circuits, which frequently include public telephone and telegraph lines as well as the service lines for the railway. Since the conditions usually affect various interests, it is not always easy to find a solution which satisfies all parties. This is particularly the case when the telegraph administration gives preference to those systems which cause the least interference. It will be well, therefore, to examine briefly the nature of these reactions and the means available for suppressing them or at least for limiting their effects.

Electrification frequently raises difficulty from the fact that communication circuits have to be removed in order to make room for the overhead construction. Even when these circuits are some metres away, it is often necessary to move them further away to reduce any risk of contact with the high-tension lines. This condition is met with on practically all the Swiss lines. Thus on Bernese railways, all the work on the communication circuits was due to this cause, and would have been equally necessary

with any other system of traction that might have been adopted. If the circuits have to be removed for mechanical reasons, obviously the removal will be so carried out that electrical disturbances will also be prevented. These disturbances result mainly from the action of earth (conduction) currents in the apparatus in the communication circuits, as well as from the static (*i.e.*, electrostatic) and dynamic (*i.e.*, electromagnetic) inductive effects of the power currents on the communication circuits.

The effect of earth currents may be suppressed by avoiding the use of an earth return for the communication circuits. This precaution is advisable not only on account of main line electrification, but also because of the numerous tramway and suburban systems, and the power and lighting systems which have temporary or permanent earth-circuits. In this connection, the kind of current makes little difference. As regards static and dynamic effects, a comparison of the several systems leads to the following conclusions.

With continuous current, static action is of no importance, as a pressure of 3,000 volts is too low. Dynamic effects make themselves unpleasant in the telephones when higher harmonics—usually produced by the driving motors—occur, particularly during starting. This trouble can be largely avoided by suitable design of the motors. The ordinary fluctuations in the load current, apart from these harmonics, are not sufficient to produce inductive effects; but sudden phenomena such as short circuits, may set up serious disturbances. To prevent damage from the latter cause, with continuous-current traction the circuits must be protected against induction at least as thoroughly as with single-phase traction. Since the pressure induced in the communication circuit is a function of the power current, the conditions with the continuous-current system—which is associated with large currents—are much worse on short circuits than with the single-phase current system; because with the latter, the impedance of the conductors prevents the creation of large currents much more effectively than does the pure resistance with continuous current. The view that inductive effects are not produced by continuous-current traction is only partly correct.

With the single-phase system, on the other hand, both kinds of induction are present. All circuits near to, and parallel with, the overhead conductors will be subjected to electrostatic action; and the nearer the lines are together and the higher the inducing pressures, the higher will be the induced pressure. The length of the parallel run has no effect. The static charge produces a noise in the telephones when equalising currents can be set up by non-uniform induction in the loops or by faulty insulation to earth. Hence with aerial lines, the wires must be sufficiently and symmetrically crossed, while all circuits and apparatus must be effectively insulated for all weather conditions. By observing these precautions, a telephone service can be maintained with ordinary apparatus even when the circuits run parallel with a 16,000-volt overhead conductor only a few metres away—as is actually the case on various Bernese lines. In case of necessity, the induced pressure can be greatly reduced by injecting a counter-pressure into a line erected in a suitable position. The same measures can also be taken with telegraphs, the care required depending on the sensitiveness of the apparatus. In general it can be stated that electrostatic action is not important when it does not exceed 200 volts to 300 volts; or, in other words, when the communication circuits are at least 50 m. to 60 m. away from a 16,000-volt overhead conductor. With cables, much smaller distances are permissible, owing to the more effective crossing of the conductors and the protective action of the lead sheath; consequently a cable can be laid alongside the track without risk of trouble.

The magnitude of the dynamic induction is a function of the length of parallel line and of the strength of the power current; so that the geometrical relations between the conductors, rails and earth and the electrical constants are important. Provided the circuits are sufficiently crossed, the inductive pressure will, in general, not disturb the telephones unless higher harmonics are produced in the driving motors or in the generators. On the contrary, equalising currents in the circuits will produce disturbances in any telegraph apparatus which is sufficiently sensitive. Thus the magnitude of the induced pressure must be kept as low as possible, and equalising currents must be prevented by equalising all the resistances by suitably crossing the lines and connecting the apparatus. Since the magnitude of the induced pressure is a function of the ampere-kilometres, it can, under given conditions, be limited by suitably choosing the length of parallel line or the distance between feeding points, either to the overhead conductor or to the rails. These points may be from the generators or from the transformer stations, each with one pole connected to the rails, or even simpler arrangements which at least draw part of the earth current back into the rails, such as the suction transformer and the auto-transformers in the three-wire system, as on the New York, New Haven and Hartford Railway.

The values measured in volts per 100 ampere-km. of parallel line on existing installations vary greatly. The following results are given for the pressure induced in a loop parallel to the railway and formed by an insulated wire and earth. In each case the values are given for circuits without suction transformers or special return leads, though the rails have bonded connectors.

Railways.	Distance between Conductors.	Volts per 100 Amp.-km.
Swedish State—single track ..	17	5–6
Prussian State—double track..	?	4
Bernese Canton—single track..	50–200	2–3
Swiss Federal (Berne-Thun)—double track	5–10	4–5
Ostermundigen-Thun	300–2,000	0·8–1

When suction or auto-transformers were used on the Swiss Federal or the Swedish State lines, the induced pressures fell to about 0·3 volt per 100 ampere-km. In this case, the distance between the track and the circuit became unimportant, because from 5 m. to 100 m. the differences were inappreciable, and only at greater distances did a reduction become noticeable.

The overhead conductor can be fed in one direction or in both directions. When fed from one end only, the whole current taken by one or more trains acts on the parallel communication lines. In the second case, where the current flows in both directions, the effects on the circuits partly neutralise one another, though not entirely, owing to the inequality in the resistances and in the feeding pressures. The induced pressure will be much smaller in the second case than in the first. With both the arrangements it will accordingly be necessary first to determine the maximum induced pressure which is permissible with the apparatus used in the communication circuits. From this the maximum permissible ampere-kilometres can be ascertained, whence the distance between feeding points with given load conditions is obtained.

From these considerations it follows that with sparse traffic, feeding in one direction is permissible for relatively long stretches; while with dense traffic, the need for shorter distances between feeding points soon occurs, or feeding in both directions becomes essential. Thus for the Bernese railways, feeding in one direction up to 50 km. along the Kandergrund-Brigue line, and about 60 km. along the Spiez-Thun-Berne-Schwarzenburg line is employed without causing serious interference in either the service signalling lines or in the neighbouring telephone lines.

Summarising briefly, the following protective devices are used in connection with the single-phase system against interference with neighbouring communication circuits. Against static and dynamic induction and direct conduction: metallic (double-wire) circuits, insulated from earth and crossed at intervals. Against static induction: removing the communication circuits to a distance of at least 50 m. to 60 m. from the overhead conductors; or with smaller distances erecting a wire for a counter pressure to compensate the inductive action; or use of lead-covered cables. In all cases, the communication circuits must be well and carefully insulated to prevent the flow of equalising currents. Against dynamic induction: Employment of a proper rail return for the power current, and limitation of the current to the permissible inductive value by suitable arrangement of the feeding points. For the latter, the following points arise—feeding in one direction or in both directions, distance between feeding points, and possible subdivision of these distances by introducing suction points in the return in the form of suction transformers or of auto-transformers in the three-wire system.

Comparing the systems with regard to interference with communication circuits, it is seen that both with continuous current and with single-phase current the communication lines have to be cleared away from the track in order to make room for the overhead conductors. If it is not possible to remove these circuits more than 60 m. away, shorter distances are permissible, in which case a comparatively cheap compensating wire is necessary with the single-phase system to neutralise static induction. Consequently the cost of re-erecting the communication lines will be about the same with either system.

As regards the devices to be used in the power circuits, the cost only becomes appreciable when with single-phase traction the three-wire system with auto-transformers is used, and to a less extent suction transformers, to reduce dynamic induction. It is equally effective, and no new equipment is required when the line is fed in both directions—the usual method with continuous-current traction owing to pressure drop. At the same time, feeding in one direction under suitable conditions has advantages with respect to the distance between, and number of, feeding points which are well emphasised in the high-tension single-phase system, as illustrated in the case of the Bernese lines. Thus with the present-day experience it is not permissible to conclude that the single-phase system will be more costly than the continuous-current system on account of interference with communication circuits to such an extent as to outbalance the other advantages of the high pressure.

Conclusions.—From the above arguments it is clear that under no circumstances can the continuous-current system be pronounced to be superior to the single-phase system. From a purely technical standpoint, both systems can satisfy the requirements of main line traffic, and the differences between them are unimportant. On the other hand, with continuous current, the capital costs will be considerably higher in consequence of the less favourable conditions of distribution. This disadvantage would remain in the event of the development of the mercury rectifier, by which the lower efficiency of the continuous-current system could be improved. Thus the choice of the single-phase system for the Swiss railways cannot in any way be regarded as a failure, but as a result of present-day experience it remains the proper solution from every point of view.

THE NATIONAL PHYSICAL LABORATORY.

(*Continued from page* 52.)

The William Froude National Tank. (Superintendent Mr. G. S. Baker, Mr. J. L. Kent, Miss E. M. Keary, Messrs. G. H. Bottomley, C. Wigley, A. W. Riddle.)—The Advisory Committee having last year recommended the desirability of increasing the facilities for research in the tank, which had been much occupied by private work, the hours of work have been lengthened and are now from 7.45 a.m. to 9 p.m., while a few additions have been made to the staff. That more time could be spared for research work, without resorting to overtime, was largely due also to the temporary decline in shipbuilding in 1921, with a consequent indisposition of shipbuilders to utilise the tank for experiments. The number of models tested, 38, was the lowest since 1913. The present practice of making special screw propellers for each model will have to be continued, since variations in rake, &c., quite common in ordinary practice, sometimes have an appreciable influence on the efficiency of the propeller. Tests made at several draughts with

different pattern screws for Messrs. Williamson and Son, of Workington, were particularly instructive in this respect, and the results will, by permission of the firm, be published. In connection with steam trial data for single-screw ships at moderate speeds, it is pointed out that ships frequently carry out their speed trials in ballast conditions which differ considerably from those at which the loaded ship will work. The Tank conducts model resistance and screw experiments under both loaded and trial conditions, and recommends that a Tank representative should attend the actual trials. The model experiments in the two conditions and the actual ship's data in the one condition will then admit of predetermining the actual steam power and the reserve power desirable.

Influence of Waves on Resistance to Propulsion and Pitching. (Mr. Kent.)—The wave-making apparatus which we described last year (ENGINEERING, July 15, 1921, page 99) has been improved to increase its range for regular and irregular waves, and the apparatus has been much in requisition also for testing screws at different immersions. An account of Mr. Kent's experiments on three models of conventional cargo boats was brought before the Institution of Naval Architects last spring (see ENGINEERING, May 28 and June 2 last). The models were identical as to their principal dimensions, but differed as to the shape of the bow section above and below water.

These differences, it was found, have an appreciable effect, and an increase in the height of the waves increases the resistance and the maximum pitching angle, without altering the pitching period, while variations in the wave-length greatly affect the resistance to the ship's speed, especially when the natural pitching period coincides with the wave period. The ship's weight should be concentrated at the centre in all but very short waves, in which the load distribution seems to be immaterial, Mr. Kent has since been able to take actual measurements of pitching, speed, &c., on a passenger cargo vessel crossing the North Atlantic, and other forms of cargo vessels are under test. There is still a gap between the data now being obtained and those published in 1905 by Froude for high-speed ships.

Manœuvring of Ships. (Mr. Baker and Mr. Bottomley.)—This research has so far been confined to the tests of "unbalanced" or ordinary rudders in conditions representing open water behind either a fin (or flat dead plate), or a ship model of 0·78 prismatic coefficient having a single screw propeller and of the type capable of economical working at 10 knots or 12 knots on 400 ft. length. When these important researches were brought before the Institution of Engineers and Shipbuilders in Scotland (ENGINEERING, vol. cxiii, p. 364) it became once more clear that very little has been done in this field, apart from the experiments of Sir Archibald Denny, made twenty years ago with towed models, and Mr. M. Denny's experiments of last year* and from some theoretical and aeronautical investigations. With the cargo-boat models Mr. Bottomley has tried four different shapes of rudder, generally at two speeds, with or without propeller running, determining the pressure, the centre of pressure, and the turning moment required to keep the ship straight. As a check experiments are now being made, with the self-propelled model free to yaw, by measuring the rudder angle required to produce a certain deviation in given time. The experiments with the rudder alone, that is, with merely a fin plate in front, are likewise made with or without the propeller running, and the scale effect has been tested with the aid of three rudders of standard type, of linear dimensions in the ratios 1 : 2 : 4. The largest of these rudders has an aft length (or width) of 1 ft., and a draught of 3½ ft.; the tests are made either at fixed angles and varying speeds, or at fixed speeds and varying angles. It would appear that, if the force on a ship's rudder be expressed by $p = k v^n$, n is less than 2, its value varying with immersion and probably other factors; but when only the scale is changed, similar conditions being maintained, the forces for such changes vary as the square of the speed. Thousands of experiments have already been made, and others are being carried out on twin-screw ships of similar form and on ships of varying fulness.

In the further investigations, Miss Keary is going to measure the rudder forces necessary to stop the swing of a ship model which is already turning.

Screw Propellers.—The chief problems studied are the effect of the propeller immersion on its thrust and efficiency and the effect on the propulsion of fore and aft position of propellers relative to the hull. The experiments are made both in quiet water and in disturbed water in which the blades "break surface," the waves either being met head on or overtaking the screw. The efficiency, it would appear, is not seriously diminished even when the blades come partly out of water, but the average thrust may drop seriously in waves at a given number of revolutions.

Aeronautical Work.—According to Rayleigh's principle of dynamic similarity the resistance to the motion of a body in a fluid depends only upon the nature and velocity of the body and the kinematic viscosity of the fluid. This applies to skin friction. Experiments with a ship model, 4 ft. in length, in air, are in moderately close accord with the resistance observed at low speed of a 16-ft. tank model. When large amounts of eddymaking are involved, however, as in the case of aerofoil blades and wires, the agreement in air and water is not so good. The difference may be due to the different experimental methods; Mr. Baker is investigating this. Modifications of an amphibian have been tested for a private firm; in these boats the wheels are a source of some trouble as they complicate the stability calculations, whilst mechanical complications arise when the wheels are to be raised. Some work for the Air Ministry concerned a new form of hull with wings so arranged that the hull will remain upright without the use of floats on the wing tips. The original design was transversally unstable, and the nose dived in acceleration; these troubles have been overcome. Other experiments deal with the blow which the bottom of the hull has to bear when striking the water, and with hulls of elastic construction having for the most part rounded sections instead of straight line floors.

Metallurgy and Metallurgical Chemistry. (Superintendent Dr. W. Rosenhain, F.R.S.; Messrs. S. L. Archbutt, J. Murdock, Guy Barr, D. Hanson and assistants.)—The department has been kept very busy, not only by its own particular work, but by the fact that the department is frequently consulted on miscellaneous problems, including, *e.g.*, the best materials for making gramophone records and the felting of furs. Mr. L. I. Bircumshaw has left the Laboratory to go to Cambridge, some juniors have been added to the staff, and Messrs. Asahara and T. Kawai, from Japan, and Mr. J. R. Freeman, of the Bureau of Standards, Washington, have worked as guests in the Department.

Equipment.—For the heat treatment of aluminium alloys and the quenching of steels a salt bath (of nitrates), 6 ft. by 12 in., 15 in. deep, and a tank, 4½ ft. by 3½ ft., 3 ft. deep, have been installed in the foundry. The latter tank is in a pit and contains 500 gallons of cotton-seed oil; to reduce the danger of an oil fire, the surface is covered with a cushion of vapours of carbon tetrachloride, produced simply by floating a tray containing a wick saturated with that chemical on the oil. In the upper storey of the Wernher Building, to which a further storey is now being added, some additional indicating pyrometers have been installed; one of these is provided with a galvanometer of Dr. Moll, of Utrecht, which forms part of the remarkable micro-photometer that Dr. Moll described to the Physical Society early in 1921. Two of the large Rosenhain metallurgical microscopes have been reconstructed with a complete geometric slide for the coarse stage adjustment, and Messrs. Taylor, Taylor and Hobson, of Leicester, have presented the Laboratory with one of their small microscopes for the direct reading of the diameters of Brinell impressions.

Light Alloys. (Dr. Rosenhain, Mr. Archbutt, Dr. Hanson.)—The Eleventh Report on "Some Alloys of Aluminium" has been presented to the Alloys Research Committee of the Institution of Mechanical Engineers and the publication has called forth inquiries and further experiments as to the use of these alloys, especially also of forgings of the Y alloy, as material for piston rings and connecting rods of internal-combustion engines. The Y alloy possesses a very high resistance to alternating stress at elevated temperatures. As regards the supposed anomalous behaviour and burning of some pure aluminium, Mr. J. D. Grogan cannot find that oxidation has anything to do with the brittleness shown by some specimens of the metal. Samples of this anomalous aluminium from various sources have been tested, and they indicate that mere heating ten times to high temperatures followed by cooling has no deleterious effect. Ternary alloys of aluminium with silicon and magnesium have been studied by Dr. Hanson and Miss L. V. Gayler, M.Sc. With respects to cast alloys it has been found that heating the Y alloy (percentages: Copper 4, nickel 2, magnesium 1½) for several hours in salt baths at 500 deg. C., followed by quenching in boiling water, improves the alloys considerably, the tensile strength rising to 21 tons per square inch with an elongation of 6 per cent. Complaints have, however, been made that these alloys are variable; that may partly be due to the workshop pyrometers, which have been observed to record 50 deg. too low in some cases. One peculiarity of these Y alloys is that they show recalescence after quenching; held in the hand they feel quite hot. Drop-forgings of small articles can be made, but the furnaces for steel drop-forgings are not suitable for these low-temperature operations.

Iron and Steel.—In the determination of the solidus curve of the iron-carbon systems, Mr. F. S. Tritton, later joined by Professor Kawai, first determined the temperature of incipient fusion by the microscopic examination of small specimens rapidly quenched. This method proving unsatisfactory they watched the change in electric conductivity with temperature through the range of incipient fusion, as Dr. Haughton had done with the Al-Ni-Cu series of alloys. Special pure examples had to be prepared in special crucibles placed in electric furnaces, air being excluded; but the conductivity change was frequently found to be too gradual. The work on light alloys having been brought to a certain completion, the department is devoting particular attention to iron alloys. Iron-nickel alloys have been studied by Dr. Hanson and Mr. Freeman, and Fe-Ni-C alloys are being taken up. The great share of the Laboratory in "season-cracking" researches has been noticed on other occasions.

Manganin and Ohmal. Physical Structure. Standardised Steel Sample.—The work of the Metallurgical and Electrical Departments on the electric resistance material manganin, one variety of which the Laboratory calls ohmal, has been so successful that the manufacture of this alloy is elsewhere being taken up commercially. In the investigation of the physical structure of metals, the specimens are put on a tensile machine, and the heat generated in plastic deformation is determined. For this purpose the delicate Moll galvanometer, mentioned above, has proved very valuable. A considerable amount of heat seems to become latent during plastic deformation. The organisation for the issue and distribution of steel standards (Mr. T. E. Rooney) is nearly complete.

Optical Glass. (Mr. V. H. Stott, M.Sc., Miss A. B. Taylor, Miss E. Irvine.)—The determination of the viscosity of glass at high temperature is one of the pressing problems of glass research. For temperatures ranging from 400 deg. up to 700 deg. C. the viscosity can be measured by the rate of twist under known torque of a rod of the glass. At higher temperatures the experiments become very difficult, and the formula seems to fail. Attempts to determine the logarithmic decrement of the oscillations of a cylinder, suspended in the glass by a torsion device, have not proved satisfactory. The viscosity also necessarily influences annealing, which, with the curious "after-working" effects, is not fully understood. At present rods for these researches are drawn on the American method—a rod is dipped into the melt, and the adhering glass drawn upward through a water-cooled cylinder.

Chemical and Aeronautical Work. Deterioration of Cotton Fabrics. Glycerol.—There is little to say

* See ENGINEERING, vol. cix, pages 349, 369.

about the general analytical work which was diminishing, thus leaving more time for research (Mr. J. Murdock). Cotton fabrics sometimes fail rapidly on exposure to the sunlight, and Dr. Guy Barr has found that the chemical changes, indicated by changes in the viscosity of solutions of cotton, give timely warnings of such a breakdown. The cotton is dissolved in cuprammonium solution, and a falling sphere is used for determining the viscosity, the values of which decrease long before tensile strength tests show a definite diminution. The use of glycerol as standard substance for viscosity measurements seems decidedly inadvisable. Glycerol (glycerin) is exceedingly hygroscopic, and its viscosity changes rapidly not only with small percentages of moisture, but also with traces of certain organic impurities which are very difficult to eliminate. Dr. Barr's experimental constant humidity box contains an aqueous solution of calcium chloride of definite strength in trays.

(To be continued.)

LITERATURE.

A Dictionary of Applied Physics. Edited by Sir RICHARD GLAZEBROOK, K.C.B., D.Sc., F.R.S. In five volumes. Vol. I. *Mechanics—Engineering—Heat.* London: Macmillan and Co., 1922. [Price 63*s.*]

FEW of us are competent to deal with the entire mass of ordered information placed at our command in this fine enterprise, as well conceived as it is generously designed. If we gauge the advance of applied physical science by the increasing space required to chronicle its achievements, we shall, by this rough measure of the progress made, surely have no feeling of disappointment or sense of failure. Rather we might marvel at the insistence, with which the need of greater attention to science and its methods is so constantly urged from all sides and by so many advocates, for it is no small difficulty to keep abreast of the flood of new facts and new applications, that capable brains are continually adding to the stock of human knowledge. Fortunately, the task is greatly simplified by the labours of many accomplished hands, who have collated the steady accretion of facts, at the same time weeding out much that has grown obsolete, or has been incorporated into more general expressions of fundamental principles. This encyclopædic work differs from many that have preceded it, in that it is produced by those who have worked strenuously and successfully to promote knowledge. Originality of treatment and masterly handling are everywhere exhibited. It is not a compilation drawn from previous works of which there are numerous examples, where it is possible to trace both the sources of the information and to note the lacunæ that have been satisfactorily bridged by later investigations.

Naturally in reviewing such an exceedingly comprehensive work as that under notice, it is impossible to do more than to record general impressions. The list of contributors first attracts attention by its variety and the acknowledged reputation of the writers. In the department of mechanics and engineering, leaders of theoretical and technical science write on subjects they have made their own by a life study, and in the section of heat, among others, the staff of the National Physical Laboratory, enjoying unique opportunities for gauging the progress of physical research, contribute a series of articles of an especially illuminating character. On the strictly mathematical side, Professor Horace Lamb holds a prominent place and here it may be said that the editor has taken a very liberal view of what constitutes applied physics. For instance, Professor Lamb contributes an admirable article on "Fourier Series," a device which though it may find application in every branch of physics, as it stands is a piece of pure mathematics.

Such a work serves many purposes, of which only a few can be mentioned. The first is obviously the provision of exact information, drawn from the most authoritative sources, and sifted by knowledge and experience. It constitutes a complete work of reference on the subjects of which it takes cognizance. With so many vehicles for publication in many languages, the student finds increasing difficulty in tracing original details of experiment or research, even if he knows that such exist. The loss of time is a serious handicap, and the disappointment frequently encountered acts as a deterrent in the prosecution of research. If the search is successful the further labour of digging out the nugget of precise information from the mass of irrelevant material in which it is embedded is discouraging, and the task of critical examination is not to be incurred without reluctance. In these volumes, the work of examination is made easy; trained minds have explored the polyglot recesses in which earlier workers have discussed the results of experiments, or explained deductions from theory. We may enter into their labours with equal confidence and gratitude. In a sense the service rendered is even greater, for though acquaintance with specialised work is necessary, full equipment demands that not less attention should be given to the results achieved in the whole sphere of related investigation. Deprived of this stimulus and assistance, to wider inquiry, the pathway to great generalisations will be missed and the results prove stunted or barren. This function is also fulfilled. The pages present a comprehensive view of the position applied science has attained to-day, so that workers in separate fields of inquiry have a complete view of the edifice physical science has erected, and may judge how far their own contributions will strengthen its foundation or add to its ornament.

Those not engaged in research, but who are eager to satisfy an intelligent curiosity, are catered for on liberal lines. Additions to the stock of knowledge is at all times continuous, and to keep pace with this accretion needs adequate assistance, but owing to the stimulus of war and the spirit of inquiry and effort it aroused, the advance has been on a colossal scale, the opportunities for study have, however, diminished in inverse ratio. The defects can now be made good without any great effort from such a collection as these volumes will present when complete. Indeed, many of the articles, which may be regarded as special monographs, are written in so inviting a form, and the interest is so sustained, that one quits them with regret. This is not surprising if it be remembered that many of them are written by men who have discovered new truths or have applied these truths to some special mechanical end.

Selection of quotation is, of course, impossible, even within the limited branches of applied physics treated in this first volume, but we can imagine if any one would learn the extent of the advance of the theory of the steam engine, he would desire no better instructor than Sir Alfred Ewing, and if he would trace the steps by which the steam turbine has become the most economical prime mover ingenuity has yet devised, he would willingly set at the feet of Mr. Robert Dawson, to gather from his teaching how the many inherent difficulties have been overcome in the past, and the outlook for the future. In calorimetry and pyrometry, Dr. Ezer Griffiths is a leading authority and safe guide, and on the theory of Internal-Combustion Engines, Sir Dugald Clerk is unrivalled. The international character of the undertaking is illustrated by the share taken by Drs. A. L. Day and R. B. Sosman, of the Geophysical Institute, Washington, U.S.A., who jointly discuss the realisation of the absolute scale of temperature. Authorities equally eminent with those mentioned must be omitted, or the catalogue would extend to an undue length, but these names may serve to show the willingness of masters to co-operate in the scheme, and the recognised pre-eminence of the colleagues the editor has invited to assist him in his task.

A feature that must engage the attention of the student of this mine of information is the evidence it provides of the tenacity and courage necessary to achieve practical success, either in the domain of discovery or invention. Such an exhibition of resolution could not be sustained without supreme confidence in the accuracy and sufficiency of the theory, on which hopes and plans have been based. Of course, there have been accidental discoveries of great moment, but steady progress depends on sound education, and the ability to embrace new and unexpected facts. It would seem that such a work as this Dictionary of Applied Physics, while recording what has been effected, also provides the means and the stimulus to further effort and endeavour. All means for providing more and better instruction in the future must be welcome, for a greater measure of scientific and practical qualifications will be required of the leaders of thought and action, who will have to attack and to solve problems of greater subtlety than those that have been successfully encountered in the past, many of which have yielded their first easy triumphs, but have left an aftermath of defects and difficulties to confront another generation of investigators. The enthusiasm for research is now at its height, and it is of happy augury that masters in their special vocation have taken the step of collecting the latest results and making them easy of access to those who are engaged in education, as also to manufacturers, who should feel that their position in the industrial world is rendered secure only by accepting the teachings of science and embodying them in practice.

The Induction Motor and Other Alternating Current Motors. Their Theory and Principles of Design. By B. A. BEHREND. Second edition, revised and enlarged. New York and London: McGraw-Hill Book Company, Inc. [Price 24*s.* net.]

ALTHOUGH the use of alternating currents for power transmission in bulk has become almost universal, electric motor driving has been more developed in the United States of America than perhaps in any other country. The system of power transmission to the propellers of the battleship U.S.S. New Mexico affords a recent example of the successful application of the induction type of alternating current motor on a large scale. In this case the motors are of the double squirrel-cage type, that is to say the rotor is provided with two separate windings, the windings in the top slots being of high resistance and high leakage reluctance and those in the lower one of low resistance and low leakage. The function of this arrangement, which is due to Dolivo-Dobrowolsky, is to improve the starting characteristics of the induction motor by providing a high-resistance winding for starting and a low-resistance winding for ordinary running. In the special conditions involved in the electric propulsion of ships the advantage obtained is the elimination of the very large control rheostats that would be otherwise required. It is, however, questionable whether this type of motor would be a success in ordinary commercial work because of the great reduction of maximum output as a result of the leakage of the low-resistance winding.

In the second edition, recently published, of "The Induction Motor," Mr. B. A. Behrend treats of the proportioning of leakage paths in this double-wound rotor machine, and shows its characteristics by means of flux diagrams, polar diagrams and torque curves. The introduction to this work revives the old Behrend-Heyland controversy of twenty years ago, as to whom the credit is due for the first suggestion of the use of the circle diagram as a means of studying the characteristics and action of the induction motor. A somewhat extensive review of the early history of this type of alternating-current machine, from the period of its invention in 1888, by Nikola Tesla, is provided and, what is rather unusual in a text-book, portraits of some of the men responsible for the development are reproduced. Throughout this survey the author gives quotations from the standard works on the subject to back his claims to priority in the suggestion of the circle diagram or to provide reasons for his contentions of unfair treatment by other writers.

This volume was originally published in 1901 from a basis of notes of a course of lectures delivered by the author at the University of Wisconsin; in the intervening twenty years between the issue of the first and second editions there have been many changes, and the book is thus considerably extended, but the two chapters on design have been cut out and there is no treatment of winding. On these two subjects the author prefers to refer readers to standard works, such as those of H. M. Hobart and also A. M. Gray on design and to A. M. Dudley on "Connecting Induction Motors," confining himself solely to the consideration of induction motor theory. The theory of fluxes and stray fields, starting from first principles, provides a

THE LJUNGSTRÖM TURBINE-

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Fig. 3.

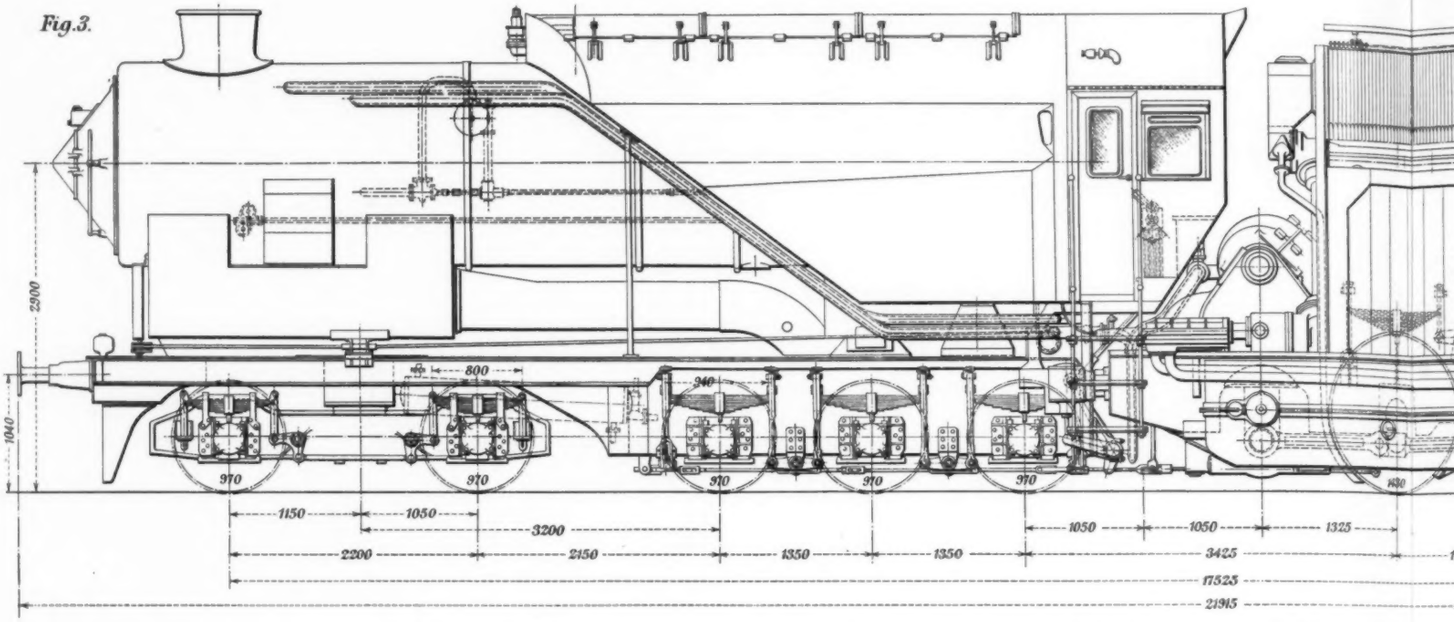
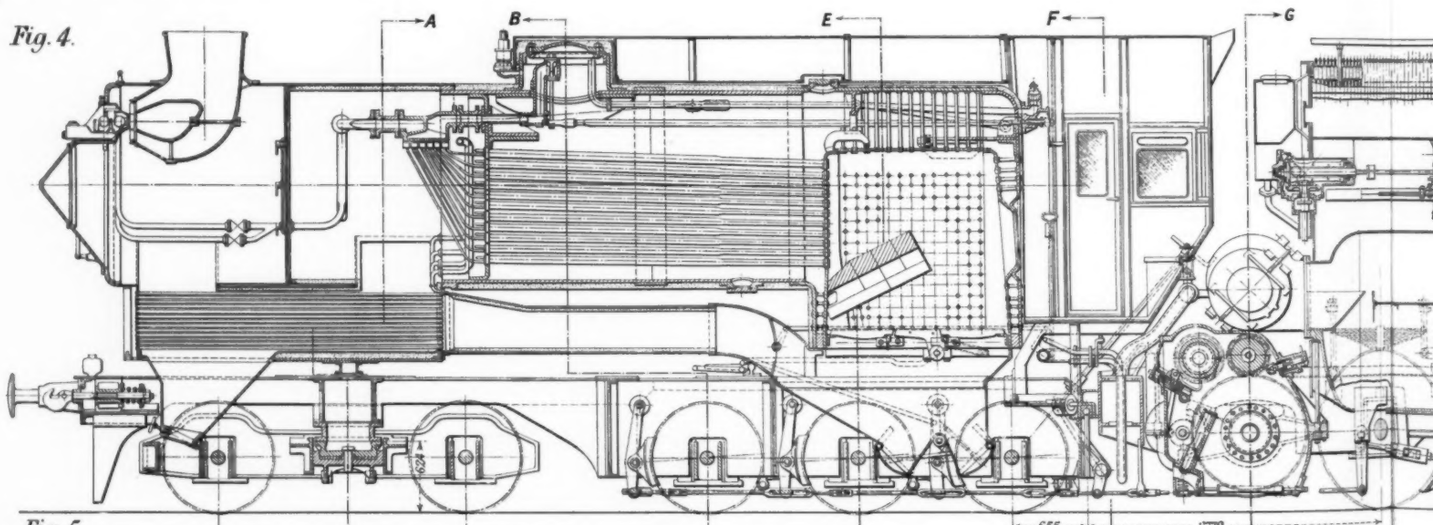


Fig. 4.



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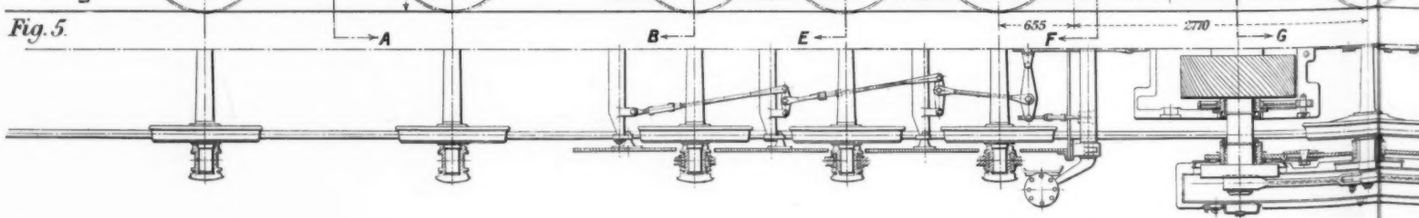

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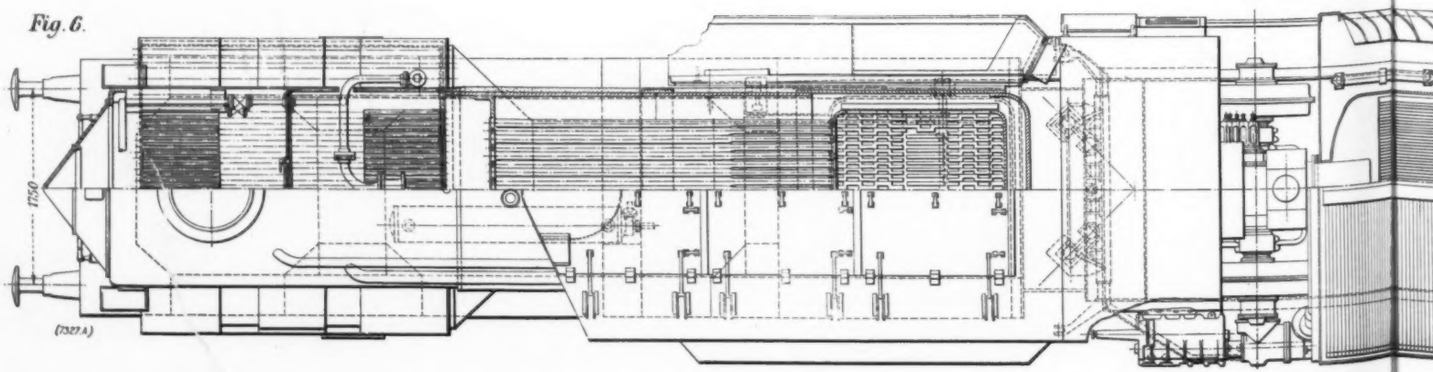

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JUNGSTRÖMS ANGTURBIN, ENGINEERS, STOCKHOLM.

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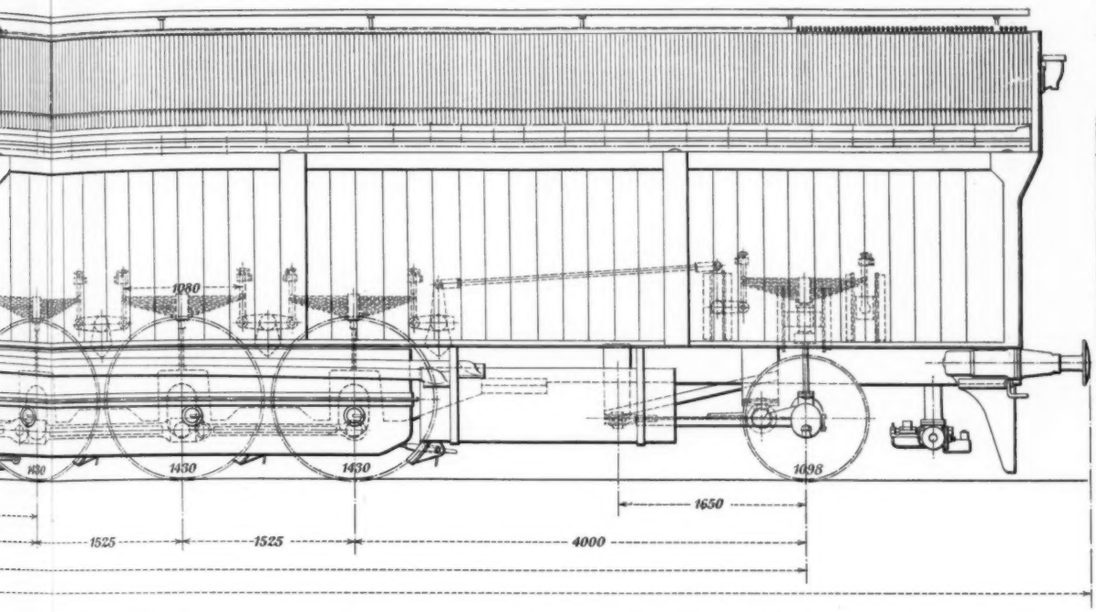

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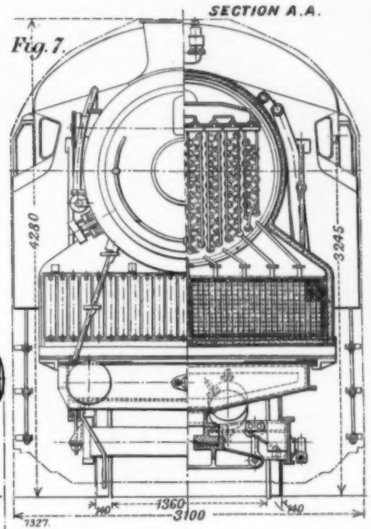

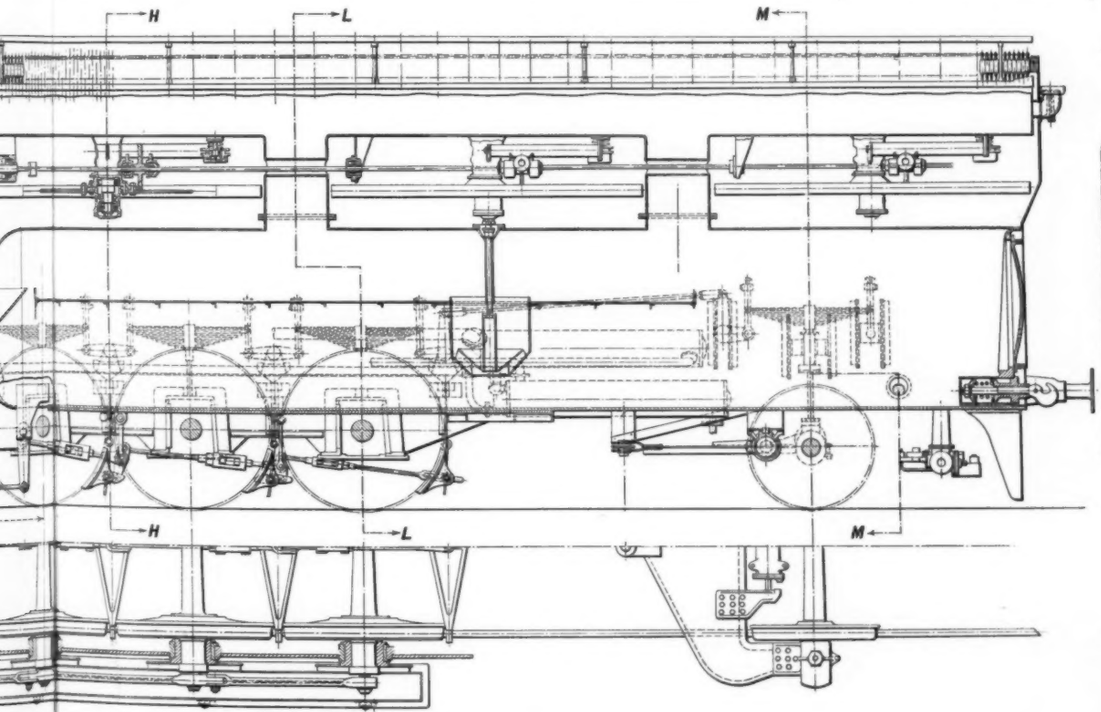

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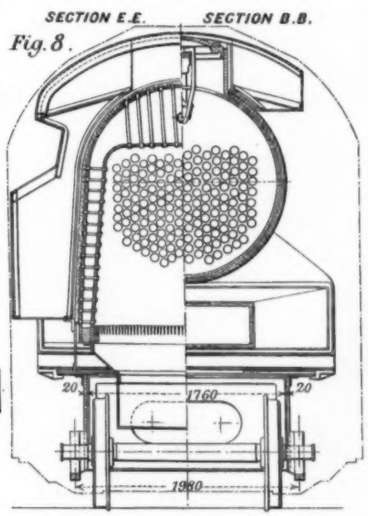
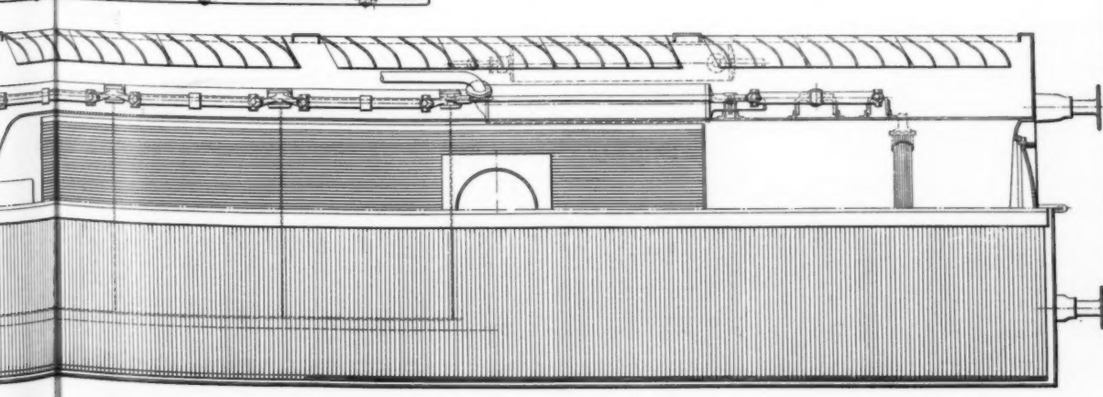
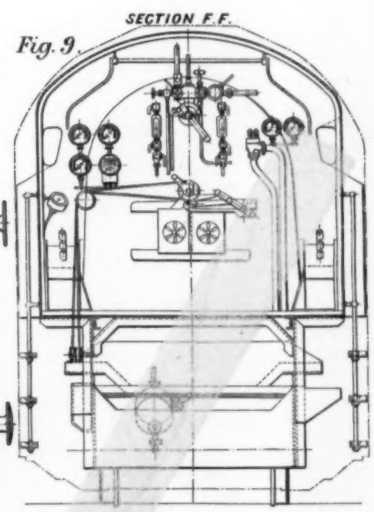


Fig. 9.





beginning for the consideration of transformer theory, of which the induction motor is of course a type. The building up of flux and polar diagrams is developed, and their use in studying machines of different characteristics is demonstrated. The elementary theory of rotating magnetic fields and their use in the induction motor follows with an acknowledged quotation extending over many pages from Kapp's "Electric Transmission of Energy." The use of the short-circuit characteristic curve in the design of this class of machinery and for the study of the influence of closed or open slots, the number of slots, air gap and pole switch on the leakage factor, is brought out by means of diagrams taken from test results on actual machines.

The author deals with the essential characteristics of squirrel-cage wound rotor machines with slip rings and with commutators, and shows their relationships to one another. The following chapters deal with series and shunt polyphase commutator motors and with methods of speed control by coupling machines and by changing the number of poles. The low power factor in induction motors has provided inventors with a task of great interest and importance, and the "Recuperator" of Le Blanc and "Vibrator" of Gisbert Kapp are taken as examples and their action discussed. The small air-gap necessary with these motors makes it imperative to be able to forecast the amount of unbalanced magnetic pull due to eccentric setting of the rotor in the stator, and Mr. Behrend gives solutions of the problem by himself and by Sumec. The impulse given to work on the single-phase motor by Lamme's proposals for single-phase traction, in dealing with the suggestions he made for the New York, New Haven and Hartford Railway, led to an enormous amount of activity, and the author shows the relationships between the various types then and later evolved, and their characteristics, in the concluding chapters of his work.

This volume is a valuable addition to the works on the theory of alternating current machinery, the references throughout to original papers, patent specifications and the works of American, British and other writers adding considerably to its value to students and electrical engineers. The work concerns itself solely with principles and fundamentals and there is an entire absence of the empirical data which is necessary for the production of actual machine design. The geometrical method of treatment has been used throughout, and thus the book is free from the pages of cumbersome and complex algebraic expressions which are characteristic of the algebraic treatment. The circle diagram is an instrument of simplicity and accuracy for the development of which the electrical engineer owes much to the author of this book.

Modern Methods of Welding as Applied to Workshop Practice. By J. H. DAVIS, of Leeds Technical School. London: Constable and Co. [Price 21s. net.]

THE rapid development of any workshop process leads to exaggerated claims by competing interests of the value of any particular application, method or system. The Great War gave an impetus to the growing use of welding processes, and the rapid strides made by them in work undertaken, with perhaps more audacity than precise knowledge, gave rise to a mischievous belief that all the processes—gas, electric arc, spot and butt welding—were suitable for the same classes of work. Only those who had facilities for testing the sometimes exaggerated claims of various interested parties were in the position of knowing the limitations in scope of the particular lines of development. It is to be hoped that the confusion that must have existed in the minds of engineers has not seriously hampered the building up of this industry on the true lines of actual suitability for any class of work. The literature of the subject, which has recently had considerable additions, has done little to remove the confusion produced, for the whole field of welding has been rarely dealt with, and then only in a very unbalanced way with exaggerated ideas of the importance of one process.

This book, the author tells us, "concerns itself with the welding processes and the materials used, and they are concisely described in their various chapters." How far the author has kept to that purpose can be seen when three-quarters of the book is devoted to gas welding, and the remainder to all the electrical processes. We regret the one-sided nature of a book bearing such a title as "Modern Methods of Welding." The author in treating of gas welding considers the execution of non-ferrous as well as ferrous welding, and describes some of the methods of gas production. The descriptions of acetylene generators would be made much more clear if sectional drawings were used for illustration rather than photographs of outside views, and this chapter could with advantage be extended. The succeeding chapters deal with blowpipes, and the nature of the acetylene-oxygen flame, safety devices, gas purifiers and the selection of plant. Chapters on methods of welding with gas and the preparation of welds follow, with instructions for performing various types of welds in steel, and references to the different faults in working likely to be found. The nature, as far as physical properties are concerned, of iron and steel, is reviewed, and the methods of dealing with cast-iron fractures is illustrated with examples of actual work. Cutting and the appliances used for this process, thermit welding and the welding of various non-ferrous metals form the subject-matter of successive chapters.

The chapters on the electrical methods of welding, we regret to have to say it, are deficient in many respects. Confusing and contradictory statements, scanty information—not always correct—are the characteristics of this part of the book. On page 211 the author states, in dealing with electric arc welding, "It is necessary, when preparing the weld, to have both edges of the line of welding bevelled, if it is over $\frac{5}{16}$ in. thick." Whereas, on page 224, he says "Sections of $\frac{1}{8}$ in. or less in thickness need not be bevelled, but should be separated about $\frac{1}{8}$ in." On page 212, electric arc welding is said to require "a supply of current, either direct or alternating, at a pressure of about 105 volts," which contrasts with the description of the output of the only generator shown (page 221) which is "wound for a voltage of 60 to 75. In no case is it necessary to have a generator of higher voltage than this. Lower voltages may occasionally be used with low circuit values." What are "low circuit values"?

The author makes the statement on page 213, in referring to a process of arc welding, "The current is direct and the voltage recommended is about 100, but much lower in amperes than with Bernodos' (Bernardos?) system, varying from 20 amperes to 75 amperes according to the thickness operated upon." Whereas, on page 220, he shows a table giving amperes used for various sizes of electrodes and thicknesses of metal as ranging from 25 to 225. The electrode diameters in this table are surely not stated as intended by the author. To use a $\frac{1}{4}$-in. diameter electrode on jobs up to $\frac{1}{8}$ in. thick, with a current of from 25 amperes to 50 amperes, is surely not to be taken seriously. On page 225, under "welding with metallic electrodes," appears the statement, "Be sure the electrode is connected to the negative terminal. If the polarity is reversed the arc will be more difficult to maintain, the electrode will not be as good as it should be." The usual practice and experience is the exact reverse of this! In referring to the tests applied to welding to determine its suitability for the construction of ships, at the foot of page 212 the author says: "The results of these tests, set out in the following pages," &c., &c., but has forgotten to give the results! The electric welding part of this book is far from satisfactory, and the volume would probably have been improved if the matter relating to electrical processes had been omitted.

Mechanical Testing. Vol. I. *Testing of Materials of Construction.* By R. G. BATSON, M.Inst.C.E., M.I.Mech.E., and J. H. HYDE, A.M.Inst.C.E., M.I.A.E., A.M.I.Mech.E. London: Chapman and Hall, Limited. [Price 21s. net.]

IN engineering books on the strength of materials the subject of mechanical testing is nearly always dealt with in one chapter and two or three illustrations, and it is supposed that in this way the subject gets its due share of attention. The appearance of this volume of over 400 pages devoted entirely to the subject of testing not only shows how wrong the general view is, but directs attention to the great developments of our ideas on the subject in recent years, and shows how intimately the application of steel to special purposes, and the testing of steel under special conditions, are concerned one with the other.

The sciences of engineering and metallurgy are equally interested in mechanical testing, and the authors of this book have combined very successfully the interests of both points of view. To engineers there is only one material called mild steel, but to metallurgists there are innumerable chemical compositions which fall under such a category, and each possesses some differentiation from its neighbours when its mechanical properties are concerned. If the insistence on this fact seems like a comment on the obvious, it must be remembered that there are numerous people still who look so far ahead that they cannot see what lies around them.

The National Physical Laboratory has always given a sound lead by stating in every case the analysis of the samples on which experiments have been made, and technical societies would enhance their publications if the giving of this information was always insisted on.

The first three chapters are concerned with the statement of the relations between stresses, strain and the different elasticity moduli, and the statements are supported by well-chosen examples and diagrams. In fact, the diagrams and curves throughout are an excellent feature of this book. The types of testing machine employed are described fully, and a comparison can be made between the features most popular in this country with those favoured abroad. The gripping of the test-piece in the machine and the calibration are details which are often forgotten, but even experienced testers will find the information given under this heading of the greatest use. The procedure in ordinary commercial testing also comes in for comment, and completes what might be called the descriptive section of this work,

The accurate determination of the limit of proportionality has always been an experiment of academic interest, but engineers are awakening to the idea that it may be of greater importance in cases where steady stresses are concerned, and it is now entering the field of commercial development in certain cases of this nature. Whether the limit of proportionality bears any relation to the ability of the steel to withstand alternating stresses has still to be determined. The work which has been done on both of these properties is gathered together here and fully discussed, and very complete information is given regarding all the methods which have been employed for this purpose, or which have been proposed.

Some progress seems to have been made in the direction of shortening the time required to test a specimen completely under varying ranges of alternating stress, developing along the lines first proposed by Stromeyer, by measuring any alteration in the temperature of the specimen under test by means of delicate thermocouples. Some of the results which are here given seem to be very promising, and the values obtained compare closely with the values obtained by more laborious methods for the limiting ranges of stress.

The strength of screwed bolts has, of course, a great importance to engineers, and the authors discuss this under the general heading of the influence of shape and change of section on strength. Martens found that screw threads subjected to plain tension were stronger by about 14 per cent. than plain bars of the same medium cross-section, and that there was no marked difference between varying forms of thread. Under impact the authors have found that a sharp V-thread only possesses about 70 per cent. of the toughness of a British fine thread. Knowing the poor quality of free cutting steel from which most bolts are made, it is probable that a more extended investigation might show some very startling differences in this respect. It has always seemed rather an anomaly that in motor car work, for instance, the greatest care should be taken in the selection of the steel for the connecting rod and in its heat treatment, but that the cap should be bolted on with bolts of an unknown and probably inferior quality of steel. The

remaining chapters of the book deal with impact tests and with the testing of bricks, concrete and stone, and the information given under each heading is complete and well arranged.

It is seldom that we have the pleasure of reading a book which strikes the individual note in so strong a key. The authors are interested in every branch of mechanical testing and their enthusiasm and clear vision have made this book a most delightful and useful production.

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Coal. Its Properties, Analysis, Classification, Geology, Extraction, Uses and Distribution. By ELWOOD S. MOORE, M.A., Ph.D. New York: John Wiley and Sons. London: Chapman and Hall, Limited. [Price 25*s* net.]

Elektrotechnik Einführung in die Starkstromtechnik. I. Die Physikalischen Grundlagen. Von Professor J. HERRMANN. Berlin und Leipzig: Walter de Gruyter and Co.

United States Geological Survey. Bulletin No. 726—E. *Geologic Structures of Parts of New Mexico.* By N. H. DARTON. Professional Paper No. 129—I. *The Flora of the Cheyenne Sandstone of Kansas.* By EDWARD W. BERRY. No. 129—G. *The Flora of the Woodbine Sand at Arthur's Bluff, Texas.* By EDWARD W. BERRY. No. 129—H. *Geology of the Lower Gila Region, Arizona.* By CLYDE P. ROSS. Washington: Government Printing Office.

"NAVAL DESIGN AND THE WASHINGTON CONFERENCE."

SIR PHILIP WATTS has made a written contribution to the discussion on the above subject at the Paris meeting of the Institution of Naval Architects, which was reported in our issue of the 7th inst. (page 20 *ante*). This discussion followed the reading of papers by Sir Eustace D'Eyncourt on "The Tendency of Warship Design as Affected by the Washington Conference," reproduced on page 27 *ante*, and by Major L. Fea, of the Royal Italian Navy, on "Some of the Consequences of the Washington Conference with regard to Naval Construction," reprinted on page 28 *ante*. Sir Philip's contribution is as follows:—

Sir Eustace d'Eyncourt's paper is a most interesting contribution to the series of papers on Warship Design which our Transactions for the past four years contain. The series includes my paper in 1919, which gives a fairly full statement of the design particulars of the ships of the British Royal Navy at the outbreak of the war, and in the same year Sir Eustace d'Eyncourt's paper which dealt with warship construction *during* the war; then followed, in 1920, a paper from Sir Eustace on H.M.S. Hood, and, in 1921, notes from him on German warship construction. Also, in the same year, there was a paper by Mr. S. V. Goodall, Constructor in the Royal Corps of Naval Constructors, on the ex-German battleship Baden; and, in our spring meetings of the present year, we had a paper by Mr. J. H. Narbeth, Assistant to the Director of Naval Construction, giving certain particulars relating to the designs of King Edward VIIth, Lord Nelson, and Dreadnought. All these papers were freely discussed by many Naval officers and Naval architects concerned with warship construction.

Sir Eustace's present paper deals with the aspect of the problem, subject to the restrictions of the Washington Conference, which in simple terms, involves the limitation of the number, displacement, and gun calibre of our capital ships. As contingent on these, we have to consider the following:—(1) The best available protection from attack by enemy aircraft. (2) The best available deck protection from projectiles dropping from enemy guns. (3) The best available above-water broadside protection from enemy guns. (4) The best available protection from underwater torpedo attack, whether fired by submarines, torpedo craft, larger vessels, or otherwise. (5) The best available protection from mine attack. (6) The highest available gun power. (7) The highest available speed.

There are, of course, other elements involved, *e.g.*, radius of action, but the above may, I think, be taken as the principal features.

Sir Eustace does not give many detailed particulars of the methods by which it is proposed to secure the best balance, between all the conflicting elements of the problem. These, of course, we cannot expect. Our own and other Admiralties, at the present moment, are engaged in maturing their designs, and no one of them is likely to make an early pronouncement on the subject. To use a well-known phrase, we must "wait and see."

Sir Eustace's remark "that all the existing types, perhaps with certain modifications were of great utility," is perhaps rather fainter praise than he intended. Those types had to meet the enemy in all the principal Naval actions, and it was with them the war was won. All the principal ships engaged at the Falkland Islands, Dogger Bank and Jutland were of pre-war design.

Sir Eustace points out that the older classes of battleships and cruisers (pre-Dreadnought ships) in almost all cases came off badly when struck by torpedoes. Most of these vessels which were sunk by a single torpedo were protected by a longitudinal vertical bulkhead along their side; when struck, the side was smashed, the adjacent compartments flooded and the ship capsized from lack of stability. In some cases the upsetting couple would have been less if there had been no middle line bulkhead. In all cases the vessels sank through insufficient stability, and if they had had sufficient stability, possibly none of them would have been lost. The newer forms of underwater protection referred to by Sir Eustace mainly depend on increasing the beam or breadth of the ship and thereby increasing her range of stability. The extent to which protection can be given against torpedo attack by placing armour and other resisting material in the side spaces is limited; a torpedo may get under the turn of the bilge and explode beyond this protection, and when the ship rolls to a comparatively small angle the whole of her bottom is exposed to attack, the target may be doubled or more than doubled and most of it will be quite unprotected. The greatest safety lies, after reducing the size of the compartments to a minimum by suitable subdivision, in providing the most stability that is consistent with other essential requirements to keep the ship upright as long as possible, if compartments be flooded in succession. It may be true that we can "at the moment" make our ships "reasonably secure" against torpedo attack, to the extent, say, of two or even three explosions, when they are upright and not rolling, but underwater attack must be expected to grow in strength, torpedoes can easily be made of any desired power and can be produced in a comparatively short time.

With regard to the greater range at which actions were fought, I am not sure that I am quite in agreement with Sir Eustace. In one of the early conferences held by Lord Fisher on the Dreadnought design, the probable course of events in an action supposing two hostile fleets or squadrons equally intent on fighting were to meet, was discussed, and it was agreed that firing would commence as soon as they got within such a range that there was a reasonable chance of hitting, say, 14,000 yards with the 12-in. guns of that day, which with 13½ deg. maximum elevation, have a range of 15,000 to 16,000 yards. This was in the minds of the officers who had to deal with the distribution of deck and side protection. (Fighting at these ranges actually occurred in the war at the first encounter in 1914 when Admiral Sturdee's squadron met Von Spee's, also at almost every encounter afterwards.) What we did not contemplate in the Dreadnoughts was that descending shell would get through our upper and main decks and fittings and travel considerable distances without exploding; it was anticipated that the shock would cause the fuse to act and the shell to burst before reaching the protective deck. This was pretty much the view held when war was declared. We soon found, however, that the German T.N.T. shell with delay action fuses could penetrate our decks and travel considerable distances before exploding. This is why we had to increase the thickness of our armour decks over the vital parts of the ship.

I concur most heartily with Sir Eustace's statement that: "The most powerful capital ship it is possible to construct still remains the prime necessity of any first-class navy." Much has been said to the contrary, but I strongly support Sir Eustace in his view. Lord Selborne, who was at one time, and a very critical time, First Lord of the Admiralty, and has given great attention to the matter, said in his place in the House of Lords, on June 20 last: "The Admiralty has done great service by standing fast on the question of capital ships. So far from the days of the capital ship being numbered, the lessons of the war prove the contrary."

Sir Eustace's paper is, in part, historical, but it is, as, no doubt, it was intended to be, mainly a suggestive one; it states some broad views on important matters and concentrates attention on the difficulties of the general problem, and I submit we are very much indebted to him for it.

Major Fea's paper is one of very great merit. It gives us another example of which many have been furnished, showing how very thoroughly Italian officers study matters relating to the design of warships. In fact, the matters involved here have been so fully and so clearly dealt with that I find very little to say inside of the general scope of what is presented to us beyond what Major Fea has himself said. I am, generally speaking, in entire accord with all Major Fea states.

There can be no doubt that the decisions of the Washington Conference create an entirely new position as regards the problem of warship design and that much time and skill will be required successfully to meet the new conditions arising therefrom.

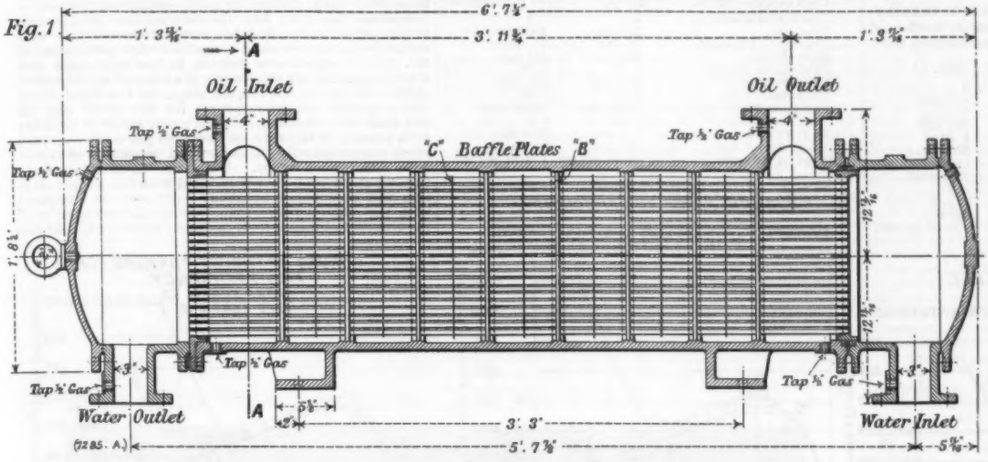
I am particularly interested in Major Fea's statement as to the possibility of reducing the number of the principal guns in a battleship when associated with great rapidity of loading, properly related to the time of the rolling of the ship, without real sacrifice in the offensive power of the main armament. I am not so sure that I agree with the proposal of Monsieur Doyère, referred to in the paper, "to employ quadruple turrets." If the guns are to be 16-in. guns, the resulting turret must not only be very large, involving special difficulties, but the concentration of such a large portion of the main armament in one turret involves a very serious risk of many guns being thrown out of action by a single blow.

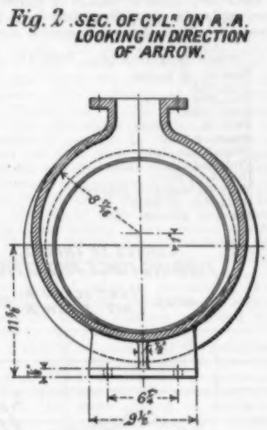
I concur in the remarks made by Major Fea in his paper as to above-water armour-deck protection, particularly where he says "In other words, it would be advisable to sacrifice the part of the ship above the principal protective deck as long as we can, at any cost, save the one underneath." Major Fea has done well, I think, in calling attention again to the desirability of incorporating, as far as possible, the protective elements of a vessel with the structural features. This method of construction was adopted by me in the designs of the modern light cruisers of the British Navy. The difficulties of actual building were, of course, increased in comparison with those of earlier ships, but the resultant gain was considerable. I submit, that we are very grateful to Major Fea for his most excellent paper.

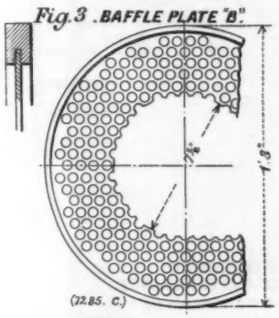
BRITISH INDUSTRIES FAIR, BIRMINGHAM, 1923.—A prospectus has been issued giving preliminary particulars of this fair, which is to be held at Castle Bromwich, Birmingham, from February 19 to March 2, 1923. The registered office of the fair is at the Chamber of Commerce, 95, New-street, Birmingham.

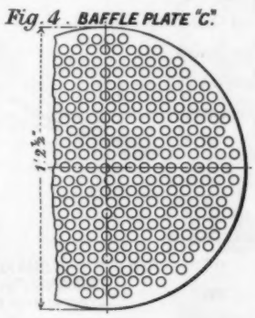
TUBULAR OIL COOLER.

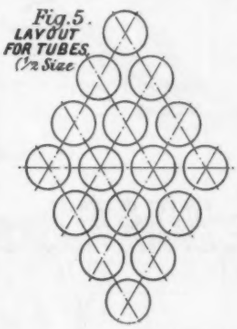
CONSTRUCTED BY MESSRS. SERCK RADIATORS, LIMITED, ENGINEERS, BIRMINGHAM.

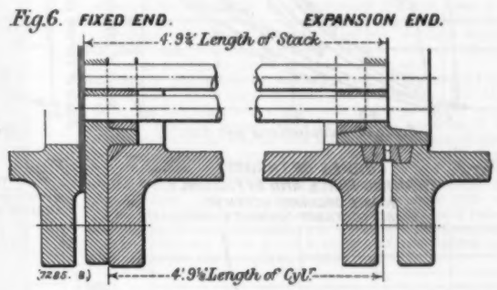












THE development of high-speed machinery, particularly of the steam turbine, has introduced many auxiliary problems which did not trouble engineers of an earlier generation. Among these the question of the cooling of lubricating oil is not the least important. This question of oil cooling is also of importance in other branches of work, as, for instance, in connection with steel-quenching tanks and electric transformers. An oil cooler would appear to be a simple appliance and, indeed, is a simple piece of apparatus, but none the less it is one in which design and manufacture have very considerable bearing on performance. The efficiency of different types varies very considerably while, as many power-station engineers know, the apparatus is one capable of making itself a considerable nuisance. It is very necessary for good performance that the oil flow should be continually broken up in some way, since if the heated oil is simply allowed to flow regularly over a cooled surface, a film of cooled, and consequently more viscous, oil is quickly formed on the surface, which pretty effectually cuts down the possible heat transference between the cooling water and the body of the oil. On the mechanical side it is desirable that the cooler should involve the minimum number of joints under oil pressure. Heated oil is a very penetrating material, and joints which the springing of a casing, for instance, tends to open, but which none the less could be kept tight without difficulty under water pressure, will almost certainly be found to give trouble with heated oil under pressure.

An oil cooler, the design of which appears to meet the requirements of the problem in an admirable way, has been brought out by Messrs. Serck Radiators, Limited, of Warwick Road, Greet, Birmingham, and is illustrated in Figs. 1 to 6 above. The cooler actually illustrated in these figures is of the firm's marine type, but coolers of generally similar construction are made for all classes of land service, and many of the large turbine builders have adopted Serck coolers. For some services the appliance is arranged vertically, which has the advantage of taking up less floor space and causing any oil deposit to settle to the bottom where it can be easily removed. In its various modifications for different work the cooler does not, however, vary in essentials, and a description of Fig. 1 to 6 will adequately cover all forms. The marine cooler shown in these figures has 250 sq. ft. of cooling surface, and will deal with the elimination of 1¼ million British thermal units per hour. The sizes built range from 10 sq. ft. to 450 sq. ft. of cooling surface.

We have said an oil cooler is a simple piece of apparatus, and it is in its details that any distinctive features of any make must lie. As will be seen the design we illustrate consists of a cylindrical barrel fitted with end chamber and a series of parallel tubes. The cooling water travels through the tubes, and the oil to be cooled is in contact with the outside of them. The tubes, which are either of copper or brass, depending on the nature of the service, are made as thin as possibly consistent with strength. This assists in the transmission of heat and saves both space and weight, compactness and small weight being two of the special features of the design. It is, however, the very thorough baffling of the oil, resulting in efficient interchange of heat between the oil and water sides, that constitutes the principle point of the design. The baffling is effected by a series of baffle plates fixed at right angles to the tubes and arranged uniformly in the length of the cooler. These are shown at B and C in Fig. 1, and are shown in end view in Figs. 3 and 4. The lay-out of the tubes in the cooler is shown in Fig. 5.

It will be noted that baffles B fit the inside of the barrel, and that they have a hole 7½ in. in diameter in the centre, whereas baffles C extend only to the outermost tubes and do not touch the casings; they have no centre hole. The result of the arrangement is that the oil flows through the centre of one baffle and around the outside of the next, so that during the greater part of its motion through the cooler it is flowing at right angles to the tubes. It thus makes very thorough contact with the tube surfaces and readily gives up its heat. The stack of tubes with its baffles makes up a single unit which may readily be withdrawn as a whole for cleaning by taking off the left-hand end covers and without breaking any oil-pipe connections. As will be seen from Fig. 1, and the enlarged detail given in Fig. 6, the left-hand end of the tube stack is anchored by means of a flange formed on the tube plate which is secured between the flange on the main body and the flange on the water header. The right-hand end is arranged to slide, the tube plate working over a surface fitted with a metallic packing, which may be adjusted by the nuts which hold the right-hand water header in place. The inside of the tubes may easily be cleaned by removing the end covers and without breaking any pipe joints. A special brush is provided by the makers for this work. Special plugs are also provided to assist in the removal of defective tubes and their replacement by new ones. For land service the stack would probably usually be returned to the makers for repair, but this procedure would not usually be convenient in marine work. The replacement of a tube is not a difficult job and could be carried out efficiently by any mechanic.

WORLD POWER CONFERENCE.—We have received a pamphlet regarding a World Power Conference being promoted by the British Electrical and Allied Manufacturer's Association in connection with the British Empire Exhibition which will now take place in 1924 in London. The conference is being organised from the Association's office, 36, Kingsway, W.C. 2. The objects of the conference are to consider how industrial and scientific sources of power may be adjusted nationally and internationally by consideration of the potential natural resources of each country, comparing experiences in agriculture, irrigation and transport; by conferences between experts, consumers, &c.; discussions on technical education, the economical aspects of industry, and the possibility of establishing a world bureau of scientific and industrial information and so on. The conference has a strong list of names forming its grand council under the presidency of the Earl of Derby, and a good technical board, while the executive committee consists of members of prominent industrial concerns in the electrical industry.

BRITISH AND FOREIGN ELECTRICITY UNDERTAKINGS.—The tables of data relating to British and foreign electricity undertakings which have hitherto been published in the early months of the year in *The Electrician*, are now issued annually in June in the form of a separate publication bound in blue cloth covers. The 1922 edition, which has just appeared, has been carefully revised, and particulars of the generating and converting plant, mains, motor hiring schemes, oil-fuel burning apparatus, show rooms, &c., of the various concerns have been included. Many new undertakings have been added, and the list of supply stations in the British Empire is now a comprehensive one. A number of new foreign concerns have also been added, and there is now a complete record of supply voltages in all parts of Chile. To engineers, manufacturers, merchants, exporters and others interested in the electrical industry, the tables will be of great service, and the publishers, Messrs. Benn Brothers, Limited, 8, Bouverie-street, London, E.C. 4, must be congratulated on their production in the present very convenient form. The price of the tables is 10*s.* net, or post free 10*s.* 9*d.*

FURTHER EXPERIMENTS ON CONTRARY-TURNING CO-AXIAL SCREW PROPELLERS.*

By General G. ROTA, Royal Italian Navy, Member.

SHIP propulsion by means of double co-axial contrary-turning screw propellers has long been a matter of research. More than once results of experimental work have been presented before this Institution, and have given rise to interesting discussions.

SCREW IN ACTION (A). FORE AND AFT. (FIG. 1.)	
Number of Blades	3
Diameter	250 mm.
Diameter of Boss	55 mm.
Mean Pitch	325 mm.
Pitch-Ratio (Mean)	1·30
Effective Pitch	325 mm.
Pitch-Ratio (Eff.)	1·30
Projected Blade Area	9343 mm²
Disc Area Ratio	0·20
Max. Thickness of Blades	12 mm.
Immersion of Axis	200 mm.
Speed of Advance	1·00 m. per sec.

1. In 1909 I had the honour of submitting the results of some experiments made in the Royal Dockyard of Castellamare di Stabia on a steam launch, whose single propeller has been replaced by two co-axial contrary-turning screw propellers. The same steam engine which drove the single propeller was employed to drive by gears the double propellers. The experiments showed that practically the same speed was obtained in both systems, with the same indicated horse-power, so that the work lost in the gear transmission was evidently regained through a better efficiency in the propellers. I rated this gain to be about 20 per cent., but whatever be the real amount of this figure, one thing came out as stated, viz., that the total efficiency of double contrary-turning screw propellers was higher than that obtained by a single propeller. Still better results could be obtained, as compared with ordinary twin screws, if the gain due to the lesser resistance of the hull, and to the absence of brackets, shafts and bossings, had been taken into consideration.

SCREWS IN ACTION.	FORE (B)	AFT (C). (FIG. 3.)
Number of Blades	3	3
Diameter	210 mm.	250 mm.
Diameter of Boss	46 mm.	55 mm.
Mean Pitch	325 mm.	325 mm.
Pitch-Ratio (Mean)	1·55	1·30
Effective Pitch	332 mm.	332 mm.
Pitch-Ratio (Eff.)	1·58	1·30
Projected Blade Area	13184 mm²	18685 mm²
Disc Area Ratio	0·40	0·40
Max. Thickness of Blades	8·4 mm.	10 mm.
Immersion of Axis	200 mm.	200 mm.
Speed of Advance	1·00 m. per sec.	1·00 m. per sec.

2. Mr. Luke, in his interesting paper presented to this Institution in 1914,* brought a valuable contribution to this question, pointing out the value of hull efficiency elements under various conditions, viz., with a single screw, with twin screw propellers on parallel axes, with double contrary-turning co-axial screw propellers (combination), with double co-axial similar-turning screw propellers (tandem), &c. Considering the arrangement of propellers in which I am now interested, viz., with contrary-turning co-axial propellers, the particulars of Mr. Luke's experiences pointed to the conclusion that if a real gain in hull efficiency was obtained in full-bodied ships, but less in fine-formed ships, on the other hand, the propulsive efficiency proper for the screw was far less than that obtained with the single screw or ordinary twin screws, in the ratio of about 86 per cent.; so that there was practically the same total propulsive efficiency with fine-formed ships. With the co-axial contrary turning screw propellers associated with full-bodied ships this will be superior by about 7 per cent. as compared with the single screw. These results did not agree with the results I obtained from my first experiments, and this induced me to undertake new experimental researches into this question.

3. In my first experiments with screw models, which I reported briefly in a written discussion on Mr. Luke's paper above mentioned (and I am inclined to think in those also of Mr. Luke and of other experimenters), the propulsive figures of each of the two contrary-turning co-axial screw propellers were not measured separately, so that it was always the value of the thrust given by the two screws and the total value of the efficiency of both which were obtained. Wishing to know exactly what are in every case the peculiarities of the efficiency of each of the two screws acting together while contrary-turning, we have succeeded in the Experimental Tank at Spezia in modifying the general arrangement of the apparatus for the experiments with model screws, so that we can now measure the thrust and turning force of each screw either separately or in combination. It is not possible here to give a description of that apparatus, but it is shown in the photograph reproduced in the perspective view. Fig. 7 opposite. The analysis of the performances of each screw enables us to investigate the influence of diameter, pitch-ratio, disc-area ratio and revolutions of the same, with the object of obtaining a higher efficiency, because, as is well known,

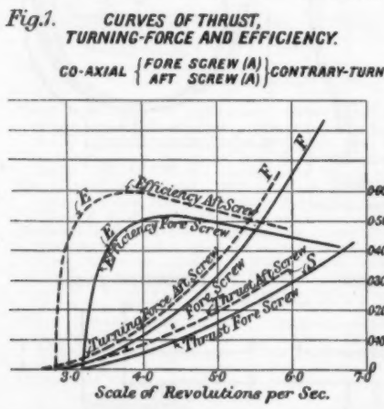


Fig.1. CURVES OF THRUST, TURNING-FORCE AND EFFICIENCY.
CO-AXIAL {FORE SCREW (A) / AFT SCREW (A)} CONTRARY-TURNING.
Efficiency Aft Screw
Efficiency Fore Screw
Turning Force Aft Screw
Fore Screw
Thrust Aft Screw
Thrust Fore Screw
Scale of Revolutions per Sec.
Scale of Efficiency (E).
Scale of Thrust and Turning Force (Grammes).

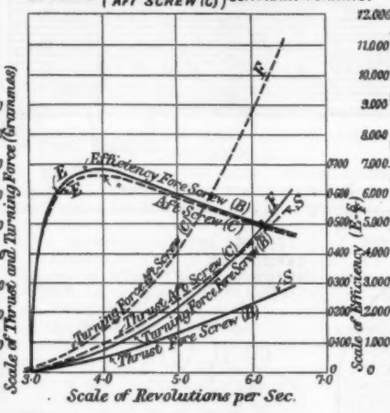


Fig.3. CURVES OF THRUST, TURNING-FORCE AND EFFICIENCY.
CO-AXIAL {FORE SCREW (B) / AFT SCREW (C)} CONTRARY-TURNING.
Efficiency Fore Screw (B)
Aft Screw (C)
Turning Force Aft Screw (C)
Thrust Aft Screw (C)
Turning Force Fore Screw (B)
Thrust Fore Screw (B)
Scale of Revolutions per Sec.
Scale of Efficiency (E).
Scale of Thrust and Turning Force (Grammes).

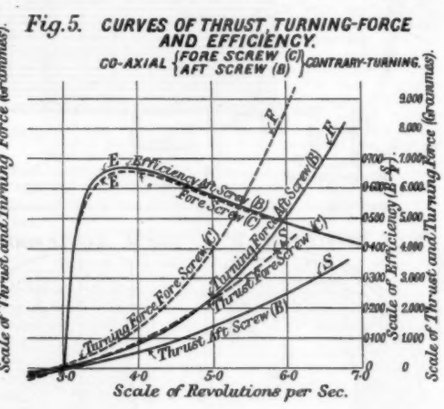


Fig.5. CURVES OF THRUST, TURNING-FORCE AND EFFICIENCY.
CO-AXIAL {FORE SCREW (C) / AFT SCREW (B)} CONTRARY-TURNING.
Efficiency Aft Screw (B)
Fore Screw (C)
Turning Force Fore Screw (C)
Thrust Fore Screw (C)
Thrust Aft Screw (B)
Scale of Revolutions per Sec.
Scale of Efficiency (E).
Scale of Thrust and Turning Force (Grammes).

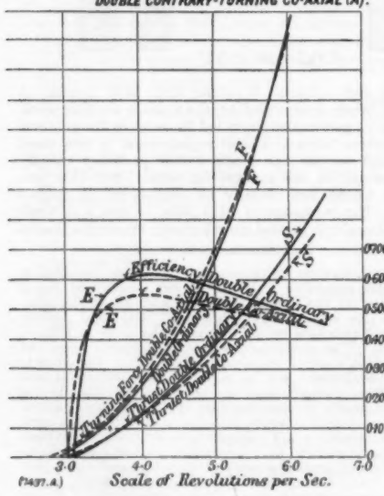


Fig.2. CURVES OF THRUST, TURNING-FORCE AND EFFICIENCY.
DOUBLE ORDINARY SCREW (A).
DOUBLE CONTRARY-TURNING CO-AXIAL (A).
Efficiency Double Ordinary
Turning Force Double Co-Axial
Thrust Double Co-Axial
Scale of Revolutions per Sec.
Scale of Efficiency (E).
Scale of Thrust and Turning Force (Grammes).

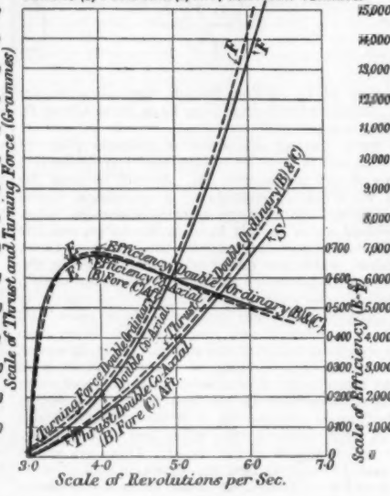


Fig.4. CURVES OF THRUST, TURNING-FORCE AND EFFICIENCY.
HYPOTHETICAL DOUBLE ORDINARY (B) & (C). DOUBLE CO-AXIAL SCREWS (B) FORE AND (C) AFT, CONTRARY-TURNING.
Efficiency Double Ordinary (B) & (C)
Efficiency (B) Fore (C) Aft Double Co-Axial
Turning Force Double Co-Axial (B) Fore (C) Aft
Thrust Double Co-Axial (B) Fore (C) Aft
Scale of Revolutions per Sec.
Scale of Efficiency (E).
Scale of Thrust and Turning Force (Grammes).

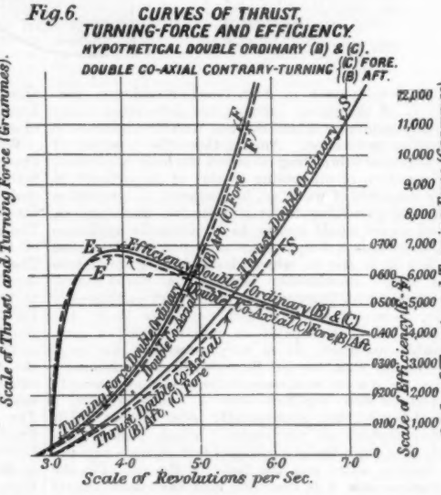


Fig.6. CURVES OF THRUST, TURNING-FORCE AND EFFICIENCY.
HYPOTHETICAL DOUBLE ORDINARY (B) & (C).
DOUBLE CO-AXIAL CONTRARY-TURNING {(C) FORE. / (B) AFT.
Efficiency Double Ordinary (B) & (C)
Efficiency (C) Fore (B) Aft Double Co-Axial
Turning Force Double Co-Axial (B) Aft (C) Fore
Thrust Double Co-Axial (B) Aft (C) Fore
Scale of Revolutions per Sec.
Scale of Efficiency (E).
Scale of Thrust and Turning Force (Grammes).

"BEHIND" EXPERIMENTS (*i.e.*, SCREW REVOLVING BEHIND THE MODEL).

Screws in Action.	Propeller Efficiency, E.	Full Model. Wake, $\frac{v-v_1}{v_1}$	Thrust Deduction, $1-\frac{R}{S}$	Hull Efficiency, $e=\frac{v}{v_1}\cdot\frac{R}{S}$	Propulsive Efficiency, $E\,.\,e$	Fine Model. Wake.	Thrust Deduction.	Hull Efficiency.	Propulsive Efficiency.
Single	0·56	0·34	0·17	1·11	0·62	0·22	0·16	1·02	0·57
Double ordinary	0·56	0·20	0·15	1·02	0·57	0·13	0·13	0·98	0·55
Double contrary-turning co-axial	0·49	0·61	0·17	1·34	0·66	0·33	0·12	1·17	0·57

* Paper read at the Paris summer meeting of the Institution of Naval Architects, July 6, 1922.

* "Further Experiments upon Wake and Thrust Deduction," Trans. I.N.A., vol. xli, page 33.

this can only be attained by experiment. In this paper, therefore, I give the results of some researches made with that apparatus, with the sole object of adding a small contribution towards the solution of model experiment problems.

4. Several sets of experiments were carried out with this apparatus, adopting different kinds of screws, and I shall describe the principal features of some of them. Symmetrical screws (type A) of 250 mm. diameter, 325 mm. pitch, and a disc-area ratio of 20 per cent., have given results which almost agree with those given by Mr. Luke. In Fig. 1 are given the thrust, turning force and efficiency curves as obtained with these co-axial screws. The difference between the two efficiency curves is considerable. The one corresponding to the fore propeller is much below the efficiency curve of the after propeller.

5. In Fig. 2 are given the thrust, turning force and efficiency curves resulting from experiments with the same propellers (A) fitted on parallel shafts as in the ordinary twin-screw arrangement; the same are compared with the thrust-turning force and efficiency curves relating to contrary-turning screws on a common axis; the thrust and turning force being the sum of the same relating to the individual propeller, and the efficiency is the total efficiency of the propelling system. From this comparison it appears that co-axial screw-propeller efficiency for the model A is inferior to that of the single screw or the twin screw of same shape acting on parallel axes to an extent which agrees sufficiently with Mr. Luke's deductions; the efficiency of the double co-axial for the case considered, being about 88 per cent. as compared with the same value for the ordinary twin-screw arrangement. With other combinations of screw propellers, however, the results were very different, so that it is possible not only to have a higher value of the ratio mentioned above, but also to have practically-equal efficiency.

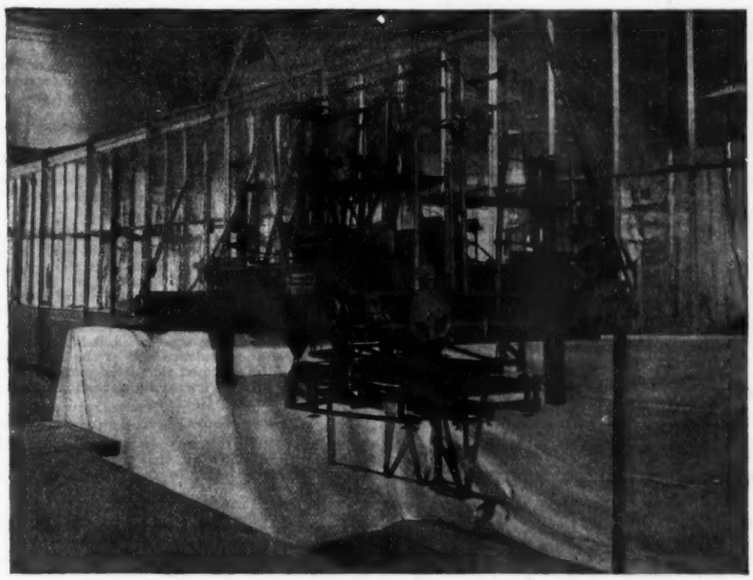


FIG. 7.

6. Further experiments were made with other screw-propeller arrangements to investigate the influence of a less diameter for the fore propeller than for the after one and *vice versâ*, keeping a constant pitch and increasing the disc-area ratio as compared with the experiments previously mentioned. In a first combination (see Figs. 3 and 4), the fore propeller (B) had diameter = 210 mm., pitch = 325 mm., disc-area ratio = 0·40, and the aft propeller (C) had diameter = 250 mm., pitch = 325 mm., disc-area ratio = 0·40. In a second combination the propellers were interchanged (see Figs. 5 and 6). The results were very interesting; the total efficiency of the co-axial screw propellers was practically the same in both combinations, and may also be considered to be the same as with equal open single or double ordinary screw propellers.

7. In view of the previous considerations, a good screw propeller efficiency can be obtained either with the two co-axial contrary-turning screws or with the single or with ordinary twin screws; so that the total propulsive efficiency, which, as is well known, is the product of screw-propeller efficiency multiplied by hull efficiency, for the double contrary-turning screw propellers will have all the beneficial influence of the high hull efficiency of the same combination compared with the corresponding figure for single and ordinary twin-screw arrangements, as was stated in the interesting communication made by Mr. Luke. Mr. Luke's investigations showed in fact that with the double contrary-turning screw propellers on a common axis the hull efficiency was 1·34 to 1·17, according to the fineness of the hull, instead of 1·02 to 0·98 as in ordinary twin-screw arrangements, and on the whole the corresponding value of total propulsive efficiency will be in the same ratio. I am inclined to think that by the use of double contrary-turning screw propellers, and with the arrangements which experience may suggest, one will obtain a great improvement in the total propulsive efficiency—not less than 20 per cent.—even without taking into account the gain which may easily be foreseen by reason of the reduced resistance of the hull itself as a consequence of the suppression of brackets, bossings, &c.

8. Other special devices to increase the ship propulsion efficiency are already in use: The well-known fixed guide blades used in Sir John Thornycroft's screw turbine propellers were shaped with a contrary curvature, as compared with revolving screw blades, so as to direct the water into a straight line aft and thus utilise the rotational component of the wake. Herr Wagner's counter-propeller is a similar contrivance designed to direct in a straight line aft the helicoidal motion of the wake. These experiments, and also the applications made with those devices, have shown, in various degrees, the possibility of increasing a ship's propulsive efficiency, but I am not aware of any advantage having been gained by adopting any of the above devices in in order to improve the total efficiency, viz., screw efficiency and hull efficiency. The double contrary-turning co-axial screw propellers would give, in my opinion, still better results, considering the contribution offered to the whole thrust by fixed guide blades or a fixed counter propeller in a second propeller.

9. The arrangement of double co-axial contrary-turning screw propellers should therefore be considered with great attention by designers in cases where the difficulties connected with the arrangement of two co-axial shafts do not appear impossible of solution. Such a case is that of cargo boats with very full hulls when the propelling machinery is far aft. There is also a possibility of utilising this system in submarines.

10. It is not possible here to enter into details of the alternative machinery arrangements in mercantile cargo boats, *i.e.*, whether steam turbines should be utilised to drive both shafts, or a combination arrangement with a reciprocating steam engine on the inner shaft and a steam turbine on the outer shaft, or whether electric motors should be provided on both shafts. Other arrangements could be devised with steam turbines and reduction gears. The double contrary-turning co-axial screw propellers would be, perhaps, suitable in submersible craft with the object of obtaining the simultaneous motion of both motors, electric and Diesel, for eventually increasing the speed on the surface. The advantages should be considerable; for example, a submersible with electric motors able to give a speed of 9 knots submerged and with Diesel motors, 12 knots surface speed. If it were possible to have all the motors acting at the same time, by adopting the co-axial contrary turning screw propeller system, the surface speed could probably be increased to 15 knots, and perhaps a little more. Under ordinary circumstances only one screw is in action, the other revolves idle, and so increases the resistance as to require a higher thrust; but considering all aspects of the problem, it should be possible to ensure conditions such as to reduce and perhaps overcome the above difficulty.

Before concluding I desire to express my gratitude to Captain A. Farina, of the Royal Italian Naval Construction Corps, for his valuable assistance in conducting the experimental work in the tank at Spezia, where he is now in charge.

THE RAILWAY ACT OF 1921.—The Railways Amalgamation Tribunal has awarded compensation to small railways, amounting to 375,000*l.* A sum of 500,000*l.* was allotted for this purpose; claims aggregated 511,250*l.*

TURBO-COMPRESSORS FOR HIGH-SPEED AVIATION.

*The Use of the Turbo-Compressor for attaining the Greatest Possible Speeds in Aviation. Specific Pressures and Weights of Air under Normal Atmospheric Conditions.**

By Professeur A. RATEAU, of Paris, Member.

THE object of this Paper is to show what must be done in order to obtain the greatest possible speed from an aeroplane; and, while avoiding prophecies in regard to the distant future, the author limits himself to that which appears to be realisable at the present time, namely, by making use of the latest improvements that have been thoroughly tested. It will be shown that it is certainly possible to exceed speeds of 400 km. (250 miles) per hour provided that the flight is made at great height, and that the power of the motor is maintained by means of a supercharging arrangement.

It is evident that the future of aviation, whether for commerce or war, depends on high speeds, and consequently in obtaining a high ceiling. The present speeds, which range from 150 km. to 160 km. (94 miles to 100 miles) per hour for commercial aeroplanes, are insufficient to give a marked advantage over railway transport. If the speed could be doubled, without prejudicing that safety which it is hoped to secure shortly, long distance transport by aeroplane would become essential for important travel and for the postal services.

In the first place it should be noted that the aeroplane is the only vehicle in which the resistance to travel is independent of speed. This is directly proportional to the weight of the apparatus for the same angle of incidence, whereas in all other classes of transport the resistance increases with the speed—more rapidly than the square of the speed in the case of boats, less rapidly than the square of the speed in the case of railway trains and automobiles—on account of frictional losses, both independent of the speed and proportional to it, which form a part of the expression for the total resistance to movement. In rising through the air the aeroplane can select a medium of the density which suits it best, whereas the boat or the wheeled vehicle is unable to change its conditions of resistance.

Human possibility is, however, necessarily limited by conditions. It is certain that the aeroplane, like the boat and the wheeled vehicle, will find a practical commercial limiting speed. At the present moment it is not possible to determine this limit with any exactitude, because much still remains to be ascertained. It does not, however, appear unreasonable to expect a speed of at least 250 km. (155 miles) per hour, whereas at the present time the steam passenger boats run at 22 knots (40 km. per hour) and railway trains and automobiles at 80 km. (50 miles) per hour for long distances.

The following table gives a survey of the figures for resistance per ton weight of vehicle:—

——	Speed.		Resistance.	
	km. per hour	m.p.h.	kg. per ton	per cent.
Cargo steamers up to ..	20	12·5	2·5	0·25
Large transatlantic steamers up to	40	25·0	6·0	0·6
Battle Cruiser	65	40·0	25·0	2·5
Railway train	100·0	62·5	10·0	1·0
Automobile	100	62·5	70·0	7·0

If these vehicles were capable of running at 400 km. (250 miles) per hour, then, by extrapolation from the formulæ for resistance, the following figures would be obtained:—

——	Speed.		Resistance.	
	km. per hour	m.p.h.	kg. per ton	per cent.
Large transatlantic Steamers at least ..	400	250	600	60·0
Railway train	400	250	150	15·0
Automobile	400	250	500	50·0

Whereas, as will be seen, the aeroplane would only require 150 kg. (15 per cent.) and perhaps as little as 120 kg. per ton or even 100 kg. per ton (12 per cent. or 10 per cent.). At these high speeds, therefore, the aeroplane assumes superiority over other methods of transport from the point of view of the motive power required.

Normal Atmospheric Condition.—In design problems concerning aeroplanes, propellers and engines, it is the specific weight ρ, in kg. per m³., of the air in which the aeroplane is flying that is the essential factor. On the other hand, the working of a centrifugal compressor depends on the pressure p (in kg. per m²). It is, therefore, necessary as a basis of calculation to ascertain as accurately as possible the laws for the decrease of p and of ρ with altitude, at least in the ordinary atmosphere of these countries. Numerous observations made by means of sounding balloons during the last 15 years have enabled these laws to be determined very satisfactorily. In particular there exist two extensive series of experiments, the results of which have been published by M. Soreau † on the one hand, for 40 observations made during the first half of 1912 at Trappes, Pavia, Uccle, Strasbourg, Vienna, &c., and on the other hand by M. Lapresle,‡ for 215

* Paper read at the Paris meeting of the Institution of Mechanical Engineers, June 15, 1922.

† Proc. of the Académie des Sciences. December 1, 1919, and *Aérophile*, 1-15, December, 1919.

‡ *Aerophile*, March 1-15, 1920.

observations made from the Lindenberg observatory near Berlin between 1906 and 1916.

At first sight the two series appear somewhat divergent, but careful analysis has shown, on the other hand, that they agree as perfectly as could be expected. The author proceeds to give the result of this analysis. The variation $d\,p$ in the barometric pressure is necessarily dependent upon the corresponding variation $d\,Z$ in the altitude Z, reckoned from sea level, and to the specific weight ρ of the air at this altitude, by the differential equation :

$$d\,p = -\rho\,d\,Z \quad . \quad . \quad . \quad (1)$$

If the temperature of the air were constant, ρ would be proportional to p, and we should have

$$\rho = \rho_0 \frac{p}{p_0};$$

hence

$$d\,Z = -\frac{p_0}{\rho_0}\cdot\frac{d\,p}{p} \quad . \quad . \quad . \quad (2)$$

whence by integration,

$$Z = \frac{p_0}{\rho_0}\log_e\frac{p_0}{p} = \frac{1}{M}\cdot\frac{p_0}{\rho_0}\log\frac{p_0}{p} \quad . \quad (3)$$

this last logarithm being to the base 10, and M the modulus.

Putting :

$$\frac{p}{p_0} = \mu \quad . \quad . \quad . \quad . \quad (4)$$

we also have

$$Z = -A\log\mu \quad . \quad . \quad . \quad (5)$$

where A is a coefficient, which, for the normal air pressure of 760 mm. of mercury (10,330 kg. per m²) and the specific weight 1·2932 times that of air at 0 deg. C. is equal to 18,400 ; or more simply 18·4, reckoning Z in kilometres. This is the well-known Halley formula ; it is not applicable to the lower strata of the atmosphere on account of the fall of temperature of the air with increased altitude ; but it applies to the stratosphere, at heights over 11 km. (7 miles), where the temperature remains practically constant up to the greatest heights attained by the sounding balloons ; it is, therefore, necessary to take the coefficient A such as to correspond to this temperature, which is − 54 deg. C.

$$A = 18{\cdot}4\,.\,\frac{219}{273} = 14{\cdot}76.$$

In the stratosphere, consequently, between the altitudes Z_1 and Z_2 and the pressures p_1 and p_2 the conditions are—

$$Z_2 - Z_1 = 14{\cdot}76\log\frac{p_1}{p_2} \quad . \quad . \quad . \quad (6)$$

We shall now examine from the means of the observations how the coefficient A in formula (5) varies with the altitude. On the diagram, Fig. 1 where Z is the abscissa and A the ordinate, corresponding points are plotted for :—

(1) The Soreau figures in curve 1.

(2) The Lindenberg figures in curve 2.

Up to values of Z = 11 km. the points obtained by experiment fall very closely on straight lines, which are, moreover, convergent, as would be expected, to a point on the axis of the abscissæ Z at 87 km. The divergencies between the points obtained by experiment and the straight lines do not exceed 0·14 per cent. in relative value for the Soreau observations and 0·17 per cent. for those made at Lindenberg. If these differences are plotted as ordinates to a much larger scale, the diagram shown in Fig. 2 is obtained. This shows the remarkable agreement between the two series of figures, an agreement which cannot be accidental and which points to complete reliability in the results obtained from the observations. The actual curves deviate in wave-form from the mean lines. Above 11 km., that is, in the stratosphere, the straight lines of Fig. 1 become hyperbolic arcs, asymptotic to the straight line A = 14·76 and parallel to the axis of Z. The small difference, amounting to 1·3 per cent., between the Soreau and Lindenberg curves, is evidently due to a small difference (amounting to about 3·6 deg. C.) between the mean ground temperatures for the two series of observations.* Up to Z = 11, or even Z = 11·5, it is therefore possible, with a degree of approximation of less than 0·17 per cent., for normal atmospheric conditions, to have

$$Z = A'\left(1 - \frac{Z}{87}\right)\log\mu, \quad . \quad . \quad . \quad (7)$$

where A′ is a coefficient having a value of about 19 and varying slightly, according to the ground temperature : 19·215 for the Lindenberg series of experiments and 18·965 for those of Soreau. From this very simple formula, which is linear in relation to Z, it may be deduced that the pressure is reduced to one-half when Z = 5·393 km. and to one-fourth when Z = 10·157 km. ; in the stratosphere the steps for reducing the pressure by one-half do not exceed 4·443 km. The next step is the investigation of the specific weights. From equation (1), they are the derivatives of opposite sign to the pressure referred to Z. Using equation (7), the value of the ratio $\lambda = \frac{\rho}{\rho_0}$ for the specific weights of air at the altitude Z (up to 11 km.) and at sea-level are easily found.

$$\lambda = \mu\,(1 - b\log\mu)^2 \quad . \quad . \quad . \quad (8)$$

b being equal to $\frac{A'}{87}$.

Making, as in the Halley formula,

$$Z = -B\log\lambda \quad . \quad . \quad . \quad . \quad (9)$$

* The observations adopted by Mr. Soreau in his calculations were all made in winter or in the spring.

This formula enables the coefficient B to be deduced from the coefficient A. Thus expanding the series, and starting from the coefficient A′ = 18·965 corresponding to the Soreau figures,

$$B = 23{\cdot}4\,(1 - 1{\cdot}12\,x + 0{\cdot}1\,x^2) \quad . \quad . \quad (10)$$

with $x = \frac{Z}{87}$.

The theoretical curve for this coefficient B is shown at 3 on Fig. 1. It is a parabolic arc differing very slightly from the straight line

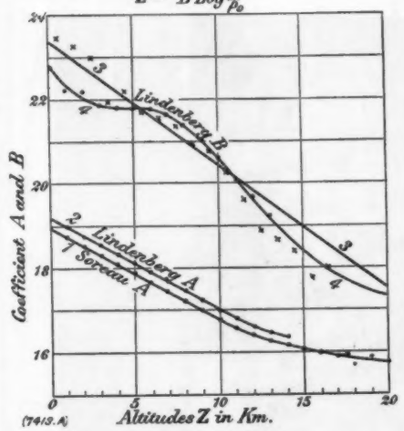
$$B = 23{\cdot}4\left(1 - \frac{Z}{78}\right). \quad . \quad . \quad . \quad (11)$$

And, since the actual curve of the coefficient A of the formula for the pressure deviates in wave-form from the mean straight line, the same should apply to the true curve for the coefficient B, with greater variations ; the maxima of the variations correspond to the points of inflexion of the curve of variation, shown in Fig. 2, and the points at which they meet the mean theoretical straight line correspond to the summits of the same curve in Fig. 2. This is what is shown in Fig. 1. The points marked as round dots, and the curve 4, have been deduced from figures given by the Lindenberg observations up to Z = 12 km. ; the curve has been continued as a hyperbolic arc because beyond this altitude in the stratosphere the temperature is almost constant. The

Fig. 1. NORMAL ATMOSPHERE, ALTITUDES = Z

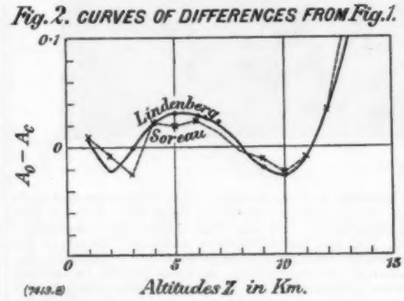
$Z = -A\,Log\frac{p}{p_0}$

$Z = -B\,Log\frac{\rho}{\rho_0}$



(7413.A)

Fig. 2. CURVES OF DIFFERENCES FROM Fig. 1.



(7413.B)

points marked by crosses correspond to the figures for pressure given by Soreau up to 17 km. They were obtained by calculation from finite differences for successive kilometres. It will be seen that, notwithstanding the necessarily large variations due to this method of calculation, the agreement with the Lindenberg results is satisfactory, except for altitudes greater than 12 km.

The pressures and specific weights for normal atmospheric conditions are, therefore, accurately given. Until further observations introduce some corrections, which apparently can only be of small magnitude, the law for the variation of ρ with altitude can be taken as that which corresponds to curve 4 of Fig. 1, which, for an approximate calculation, can be taken as a straight line, or, better still, for altitudes varying between 3 km. and 6·5 km., by the horizontal line B = 21·8, and, for altitudes between 6·5 km. and 15 km., by the straight line

$$B = 24{\cdot}3 - 0{\cdot}385\,Z \quad . \quad . \quad (12)$$

The specific weight of air at normal atmospheric pressure, according to the curve, is reduced to one-half of that at ground-level at 6,530 m. altitude, and to one-fourth at 11,830 m. altitude : beyond this, in the stratosphere, the steps to reduce the specific weight by one-half are equal to 4,443 m., as in the case of the pressure.

With regard to the temperature of the air, this decreases from 5 deg. C. to 7 deg. C. per km., according to the altitude and the season of the year, until the stratosphere is approached. This decrease in a stable atmosphere can in no case exceed 10 deg. C. per km., which is the figure that corresponds to the adiabatic expansion of air in the upper strata ; if this were not the case, a body of air which had begun to rise would continue in motion, because, at each successive level it would have a specific weight less than that of the surrounding air.

THE AEROPLANE. INVESTIGATION OF THE CONDITIONS FOR HIGH SPEED.

The supporting surface is given almost entirely by the wings, a little by the fuselage of the aeroplane, and a small amount also by the tail-plane. On the other hand, the resistance R to forward movement is not only due to the wings, but also to the fuselage, the tail and all the accessories : struts, stays, wires, &c. These forces are proportional to the specific weight ρ of the surrounding air, on the one hand, and to v^2 on the other hand, v being the velocity of the aeroplane in metres per second.

For horizontal flight it may be taken that

$$\left.\begin{aligned} R &= X\,\rho\,v^2 \\ W &= Y\,\rho\,v^2 \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (13)$$

W being the total weight of the aeroplane in kg. X and Y two functions of the incidence of the wings alone, characteristic for the particular aeroplane. The ratio $\frac{R}{W}$, equal to $\frac{X}{Y}$, is, therefore, also a function of the incidence alone. The term "relative resistance" will be used for this and be denoted by f. The minimum value of f, usually obtained for angles of incidence approximating to 4 deg. for existing types of aeroplanes, will be called the "fineness" of the aeroplane. Attention may be drawn to the fact that the fineness of the best aeroplanes flying is about 0·12 ; that in the types now being designed it is hoped to reduce it to 0·10 and even less, perhaps even to 0·08, and that the flight at ceiling height is obtained when the incidence is exactly equal to that for this minimum value of f or, more accurately, as the author has shown elsewhere, slightly greater on account of the increase of the slip of the airscrew with the incidence, an increase which allows the motor to revolve a little faster and, consequently, to give more power.

Let S be the area of the wings in square metres ; the coefficient Y is proportionate to it and

$$Y = K_y\,S \quad . \quad . \quad . \quad . \quad (14)$$

Similarly for the portion X_a of the coefficient X, which corresponds to the resistance of the wings only,

$$X_a = K_x\,S \quad . \quad . \quad . \quad . \quad (15)$$

It should be noted that the coefficients K_x and K_y are here referred to the specific weight ρ equal to unity, whereas ordinarily they are made to correspond to the arbitrary specific weight 1·225. The change can therefore be made from one to the other by dividing by 1·225.* With regard to the portion X_c of X, which corresponds to the resistance of the fuselage of the aeroplane and to the various accessories, it is approximately independent of the incidence and of the area S of the wings. It will be assumed that it is quite independent of these, and, with a view to simplification of notation X_c will be replaced by C, giving

$$X = C + K_x\,S \quad . \quad . \quad . \quad (16)$$

The power P (in kg m. per second) developed by the motor, multiplied by the propelling efficiency η of the airscrew is equal to the resistance R v of the aeroplane.

$$K\,v = \eta\,P.$$

Substituting $X\,\rho\,v^2$ for R and replacing $\rho\,v^2$ by $\frac{W}{Y}$.

$$v = \frac{\eta\,P}{f\,W} \quad . \quad . \quad . \quad . \quad (17)$$

is obtained, an equation which is very simple and gives v as a function of the useful work η P of the propelling mechanism, of the total weight W of the aeroplane and of its total relative resistance f. But it does not show clearly the influence of a change in the supporting surface S. One would be tempted to introduce the minimum value for f, or the fineness of the aeroplane. This would not be correct, because aeroplanes normally fly with angles of incidence much smaller than those of the ceiling. It is better, therefore, to treat the terms relating to the wings and those relating to the fuselage of the aeroplane separately. Then from equation (16) is obtained—

$$C\,\rho\,v^3 + W f_a v = \eta\,P. \quad . \quad . \quad (17A)$$

where C is the coefficient of resistance of the fuselage and f_a is the relative resistance of the wings alone.

This equation shows at once that the useful propelling power η P being given (it is actually assumed that the motor is revolving at its maximum speed) and the fuselage of the aeroplane and its weight, the maximum speed of the aeroplane is obtained when the incidence of flight, in air having the specific weight that has been determined, is such that f_a, the relative resistance of the wings alone, is a minimum, and it is known that this optimum incidence of the wings is, for the usual form of profile, approximately 1° 30′.

Nevertheless an attempt to obtain this condition exactly would lead, as will be shown by an example, to extremely small and, consequently, dangerous, wing area if flight had to be effected near the ground.

Even in theory the maximum speed corresponds to a slightly greater incidence, and, consequently, to a still smaller wing area, because, as the latter is reduced, the weight can obviously also be reduced, so that the total weight of the aeroplane, instead of being constant, as had been assumed, is slightly diminished, and this acts in the same direction as the reduction in f_a. But it

* It is to be regretted that from the commencement of laboratory work the coefficients were not systematically referred to $\rho = 1$, instead of to $\rho = 1{\cdot}225$.

must be noted that the relative resistance of the wing does not vary appreciably if a value for the angle of incidence is taken appreciably inferior to that which gives the minimum. It will, therefore, be of advantage to do this, in order that the area of the wings may be as large as possible. Applying these formulæ to a concrete example, such as the Nieuport aeroplane, confirmed by the success with which Mr. Sadi-Lecointe obtained a speed of as much as 330 km. per hour (over 200 miles per hour) or 91·7 m. per second. The particulars of this aeroplane are :—

$$W = 980 \text{ kg.}, S = 11 \text{ sq. m.}, P = 320 \times 75,$$
$$\eta = 0{\cdot}8, \eta P = 19{,}200.$$

From these figures it can be deduced in the first place from the second formula (13) that—

$$K_y \rho = 0{\cdot}0106,$$

which corresponds, according to the characteristics of the wings, to an incidence of flight approximating to $-2°$.

Then, from the first of the equations (13) and (16) it is found that

$$(C + K_x S) \rho = 0{\cdot}0249.$$

Now, the coefficient of resistance C of the fuselage of the aeroplane is, as has been stated, equal to 1·6 times that of the wings. Hence

$$C \rho = 0{\cdot}0153 \text{ and } K_x \rho = 0{\cdot}00087,$$

whence $f_a = 0{\cdot}082$. The relative resistance of the aeroplane as a whole is $f = 0{\cdot}213$. We are, therefore, far from such fineness as 0·12 obtained by aeroplanes having large wings, and for which the resistance of the fuselage is about equal to that of the wings at the angle of incidence at the ceiling.

The next step is to find the maximum speed which would have been obtained if the constructor, while keeping the fuselage the same, had attempted to reduce the wing-surface still further so as to allow of flight under the optimum angle of incidence of about 1° 30′, assuming that the weight was not altered. In equation (17A) C ρ, W and η P are not altered ; but f_a will have been diminished ; it will probably have a value of 0·05 instead of 0·082.

The equation then becomes

$$0{\cdot}0153\, v^3 + 49\, v = 19{,}200 ;$$

whence $v = 98$ m. per second—that is, 352 instead of 330 km. per hour.

The advantage is appreciable ; but whereas the $K_y \rho$ at this incidence had increased to approximately 0·025, the area S of the wings would have been reduced to

$$\frac{W}{Ky\, \rho\, v^2} = \frac{980}{0{\cdot}025\ (98)^2} = 3{\cdot}9 \text{ sq. m. only.}$$

The relative resistance of the aeroplane would have fallen to 0·184, instead of to 0·213, notwithstanding the great reduction in wing area.

This example shows conclusively that it is very difficult to exceed speeds of the order of 350 km. per hour near the ground ; the density of the air there is too great. This requires the wings to be reduced to very small dimensions, which renders the manipulation of the aeroplane difficult, and necessitates speeds of taking-off and landing that are extremely dangerous ; it diminishes the fineness of the aeroplane and causes an excessive load on the wings per square metre. To overcome these difficulties the only method is to find layers of the atmosphere of less density by rising to high altitudes. With the same fuselage, the coefficient C remaining constant, it will be seen that in equation (17A), which gives v, the coefficient C ρ of v^3 diminishes proportionately to ρ ; but the power P of the motor would fall still more rapidly, so that the speed would diminish if it were not for the method of restoring the power P of the motor by means of the turbo-compressor.

Going back to the aeroplane of Sadi-Lecointe, suppose it to be flown at a height of 6,500 m., for example, where the specific weight ρ is reduced to one-half of that at ground-level, and with the same incidence. The wing area will be greatly increased : 18 sq. m. instead of 11 sq. m. The aeroplane becomes more like the normal type. But the weight will increase appreciably, not only on this account, but particularly because of the whole arrangement of the turbo-compressor, the weight of which is about 65 kg. A total weight of 1,100 kg. instead of 980 kg. is, therefore, taken.

Equation (17A) then gives $v = 108$ m. per second—that is, 390 km. (242 miles) per hour. The relative resistance falls to 0·161. Now, flying the aeroplane at 11,800 m., where the specific weight of the air is only one-fourth of that at ground level, and giving it a wing area such that $f_a = 0{\cdot}06$, and supposing the load to be increased to 1,200 kg., equation (17A) then gives $v = 135$ m. per second, or 486 km. (302 miles) per hour. The wing area will still be about 18 sq. m. and the relative resistance will fall to 0·118. But at this very great altitude, the lives of the pilot and of the passengers could not be guaranteed, except in air-tight cabins in which an air-pressure approximately equal to that at the ground would be maintained. This would cause an appreciable increase in the total weight of the aeroplane, and moreover it could only be obtained with appliances of much greater size than that which has been taken as an example of the application of the formulæ. It is, however, in this direction that an attempt must be made to obtain very high speeds, of the order of 400 km. to 500 km. per hour (250 miles to 310 miles per hour). The matter is being considered from various sides. The problem is very difficult ; it will certainly be solved, as many others have been, in a period of a few years if sufficient pains are taken and the necessary funds are forthcoming. So far as the turbo-compressor, which should be capable of compressing air from 0·2 up to 1·0 atmospheres, is concerned, there is no serious difficulty.

While waiting for the air-tight cabin it is possible to remain at altitudes of about 6,000 m., where the conditions for life are made possible by the use of oxygen apparatus for respiration, or even without this help. The progress actually in sight will doubtless allow an appreciable reduction in the weight of the fuselage and of the wings, even though nothing can be done for the motor ; an improvement in the dynamic qualities of the wings and a reduction of the passive resistance of all the "dead" portions of the aeroplane will be obtained, and this will enable the coefficient $\frac{R}{W}$ for normal flight, to be reduced to less than 0·12. It has also been proposed to flatten the fuselage considerably by placing the motors and the petrol and oil reservoirs, and even the men in the wings. This would not be possible except in the case of very large aeroplanes and of very thick wings. It might thus be possible to reduce $\frac{R}{W}$ in normal flight to considerably less than 0·12, even to 0·10. But, in order that too great a demand should not be made on the possibilities of the future, the value of 0·12 will be taken.

If, on the other hand, a mean weight of 6 kg. per horse-power is taken, which can now be obtained for a long distance flight, equation (17) then gives a mean speed of 300 km. per hour ; it would be sufficient to reduce the mean weight per horse-power to 4·5 kg. in order to attain 400 km. per hour. This is doubtless not possible for long-distance machines, but it is certainly attainable for military aeroplanes which do not have to carry a heavy load of fuel. This is the order of magnitude of the speeds that it is to be hoped will be attained shortly by the assistance of the turbo-compressor. It would be advisable, it appears, to encourage the invention of apparatus capable of giving these speeds by means of suitable competitions. Flights near ground level have given almost all that could be expected. As high speeds can only be obtained at great altitudes the time has come to abandon flight near the ground and to introduce regulations for competitions which will involve long distance flights at any height.

The Turbo-Compressor.—The indicated power of an aviation motor is roughly proportional to the weight of air that enters the cylinder in unit time, always supposing that the carburation is regulated in the same manner ; but it is not this power that is of importance ; it is the net power at the airscrew shaft, which is less than the indicated power by the total expended in piston friction, the friction in the connecting-rod ends and of the shaft in its bearings, losses due to vibration, losses in valve actuation, and in operating the oil and water pumps and driving the magnetos.

So many factors influence these losses that it is impossible to produce a simple and exact formula connecting the effective power with the air consumption. At best, therefore, it can be said that the present motors give about one horse-power per gramme of air introduced per second when working at normal atmospheric pressure; a little more (or, rather, a little less) than one horse-power, according to whether the motor is above or below the average, whether the lubrication is better effected or no, whether the pressure at the end of the compression is higher or lower, &c.

The torque Q is approximately independent of the speed of rotation within practical working limits, at least for non-rotary motors, and may roughly be given by the very simple formula :

$$Q = A\ (\rho - \gamma). \quad . \quad . \quad . \quad (18)$$

A being a coefficient peculiar to the individual motor, ρ the specific weight of the induction air, γ a constant, characteristic for each motor, differing little from 0·12. It will be seen at once from this that, as the aeroplane rises, and the density of the air diminishes, the torque and the power decrease more rapidly than ρ. At 6,500 m., where ρ is reduced to one-half, the torque falls to 44 per cent. of the value at ground level. It would fall to zero if the formula remained true when ρ fell to 0·12, that is to say, when Z is approximately 18 km. It is this rapid fall in the torque which causes the drop in speed on the level and in climbing, and which limits the height of the ceiling. At constant torque the incidence of flight would remain the same as also would the outflow and the power absorbed by the airscrew ; speeds for horizontal flight would increase inversely as the square root of the density, and in theory the ceiling would cease to exist. The limit would be attained by the maximum speed permissible for the revolutions of the motor.

From the first days of aviation many ingenious inventors had thoroughly foreseen and shown that it would be possible to overcome this serious difficulty by compressing atmospheric air in the first place in such manner as to feed the motor at a higher pressure, and thus to enable it to draw in a greater charge of air ; but no one, so far as is known to the author, had endeavoured to find a practical solution, until in 1915 the question was put to him by the Lorraine-Dietrich Company. They thought that a solution might be obtained by the use of a centrifugal fan driven by the motor itself through a speed-increasing gear, and they sought the assistance of the author because of his experience in this class of machinery.

After considering this problem, as well as several others, the author recommended that no trials should be made. It appeared in fact, that the gearing and the fan, which should in this case be formed of several revolving wheels, would be too heavy and would take up too much space ; moreover, the permanent connections of the fan to the motor would overload the latter uselessly at starting, and would introduce an element of risk. Finally, as will be seen later, in order to re-establish in a suitable manner the initial pressure found at ground level, it is necessary that, as the aeroplane rises, the speed of rotation of the fan should increase progressively in the ratio of 1 to 2·5 at least, a ratio which is much greater than that of the speeds of rotation of the motor. It would, therefore, be necessary, in order to make good, to insert a change-speed gear, as on automobiles, and this is not practicable on an aeroplane. This arrangement did not appear to the author to be acceptable. It was this method, however, that was tried later by the British Aeronautical Service, the author believes without success, and by the Germans, who, towards the end of the war, began to turn out some appliances of this class. It may be presumed that, except perhaps in special cases, this solution will be abandoned in favour of that which has been perfected in France.

The author had set the problem aside until, in August, 1916, Mr. Bastiou, the pilot, came to ask his help in following up some investigations which he had commenced. He had clearly seen, from his own work, the advantages to be obtained from supercharging and from running the motor at constant torque ; but he also sought for a combination of a compressor driven by the motor.

On further investigation the author found that the objection would be avoided by a different combination consisting of the coupling of the fan not to the motor itself, but to a turbine driven by the exhaust gases. Provided that the rotor could be caused to revolve at very high speed, the appliance would be small and light, a single wheel being sufficient, both for the compressor-fan and for the turbine. Moreover, this would give complete independence of the motor and of the supplementary turbo-compressor, because an ordinary exhaust cut-out capable of being operated by the pilot would enable him to turn the gases through the turbine or to exhaust direct to the atmosphere and even to regulate the action progressively.

In any event, the scheme would not be practical unless sufficient power were available in the exhaust gases to compensate for all the losses in the fan on the one hand, and in the turbine on the other hand, without causing excessive back-pressure on the motor. Fortunately, by a lucky chance, the compensation is found with a back-pressure on the motor approximately equal to, or slightly higher than, the pressure at which the fan must deliver, so that it is possible in practice at any altitude, to restore the motor to almost the same conditions as when running at ground-level ; the energy obtained by the expansion of the exhaust gases, between the pressure at the ground and the pressure at the altitude at which the aeroplane is flying is, in fact, sufficient to compress the air-supply to the higher pressure from the lower. That this is the case can be easily shown in the following manner.

To begin with it is well to note that if there is no leakage, the weight of the gases leaving the motor is slightly greater than the weight of the air that enters it, because, to the air taken into the carburettor must be added 5 per cent. to 6 per cent. of petrol ; next it must be noted that the gases, which leave by the exhaust from a motor running under normal conditions at ground-level, are at a temperature of 800 deg. C., or at about 750 deg. C. (or 1,023 deg. absolute C.) after being cooled in the exhaust manifold between the motor and the turbine. If the aeroplane is at an altitude at which the atmospheric air is at a temperature of -20 deg. C., for example, that is 253 deg. absolute C., the volume of gas leaving will be greater than $\frac{1023}{253}$ or equal to four times the volume of the air entering, measured at the same pressure, and, consequently, working between the same pressures, the gas that is exhausted should theoretically be able to give four times the work strictly necessary for the compression of the air. Hence it will suffice if the turbo-compressor unit has an efficiency equal to the inverse of 4, that is, of 25 per cent., in order that the appliance may work in practice within the given conditions.

Now, it is very easy to make, even without going to the most perfect forms, a fan and a turbine in which the losses of energy of every kind are less than the actual useful work done. The turbine and the fan having each individually an efficiency of over 50 per cent., the combination has an efficiency equal to the product, or an overall efficiency of 25 per cent. The actual apparatus has 27 per cent. ; and given a slight increase in weight and space, the author thinks that it should be possible to obtain rather over 30 per cent. The solution, therefore, appears quite hopeful.

The above brief description does not take into account it is true, the variations of temperature which necessarily occur during the expansion of the exhaust gases in the turbine and during the compression of the air in the fan. A perfectly correct theory, which can easily be proved, leads to a formula which is translated graphically in Fig. 3. The ratio of the pressure p_0 of compression of the fan (which is also very closely the pressure of the induction of the motor) to the actual atmospheric pressure p at the actual apparatus, is plotted as abscissæ ; and the ratio of the exhaust pressure p_1 of the motor to the pressure p_0 of the supply is plotted as ordinates. The corresponding curves at various values of the coefficient $\tau = \eta \frac{T_1}{T}$ which governs this ratio $\frac{p_1}{p_0}$ where

η is the overall efficiency of the turbo compressor,

T_1 the absolute temperature of the exhaust gases on entering the turbine.

T the temperature of the air drawn in through the compressor fan.

From this curve it will be seen, for instance, that

if at the altitude of 5,400 m. it is desired to re-establish the pressure at ground level, that is to say, to obtain a ratio $\frac{p_0}{p}$ of compression equal to 2, with $\eta = 0{\cdot}27$, $T_1 = 1{,}023$ deg. absolute C, $T = 253$ deg. absolute C., which gives to τ the value 1·1, it would be necessary that $\frac{p_1}{p_0} = 1{\cdot}09$ in order that the turbo-fan should fulfil the required conditions, and this without taking account of the 5 per cent. to 6 per cent. of petrol introduced in carburation. It follows from this that there is a back pressure on the motor of 0·09 kg. per cm.² over and above that when running at ground level. This is hardly appreciable. The curves drawn on the diagram, up to $\tau = 1{\cdot}3$ rise for values of $\frac{p_0}{p}$ greater than 1·7. It appears therefore that, if it were desired, at altitudes above 10 km. to restore the atmospheric pressure at the ground, that is to say, if the ratio of compression were to be greater than 4, instead of 2, which has just been considered, it would be necessary to allow for a greater back pressure on the engine. With regard to this it should be noted :—

1. That with increased altitude, the temperature T of the air will fall, whereas T_1 will remain sensibly constant ; from this arises a considerable increase in τ.

2. That two-stage compression will give improved efficiency to the compressor if provided with an intermediate cooling radiator.

The general formula shows, for example, that for a ratio of compression of 4, with $T_1 = 1{,}023$ deg. absolute C, $T = 220$ deg. absolute C., which exists on the average for Z = 11 km., then, if the overall efficiency of the turbo-compressor attains 0·316, this will be sufficient, and it is a figure which can be obtained when the back pressure p_1 at the motor is exactly equal to the pressure p_0 of compression by the turbine. The coefficient τ then rises to 1·47. From this it will be seen that it is quite possible at any altitude to restore the working conditions of the motor to those existing at the ground level.

But the actual designing of the machine presented peculiar difficulties. Even with the large amount of data and experience obtained by previous work in this field it was not possible to attempt a solution without some fear as to the result.

In order to re-establish the air pressure at ground level at an altitude of 5,400 m., that is to say, to double the air pressure, which was the object in view, it was necessary to obtain, at the periphery of the compressing turbine, a tangential speed of 380 m. per second, that is, taking a diameter of 24 cm. as suitable, a speed of rotation of 30,000 r.p.m. This greatly exceeded anything that had been previously achieved. The action of centrifugal force is very great at this speed. The portions of the metal that are furthest from the axis, for example, exert a pull in the direction of the radius equal to 123,000 times their weight ; a gramme of matter gives rise to a tensile force of 123 kg. Moreover, the turbine is required to revolve in gas at 750 deg. C., or more accurately rather less, say 650 deg. C., on account of the expansion in the distributor—that is to say, it is almost at a red heat ; and, at this temperature, all metals lose a great proportion of their tensile strength ; whereas the wheel of the turbo-compressor would be subjected to very low temperatures, ranging down to − 55 deg. C. at high altitudes, when the usual metals of construction become extremely brittle. The shaft is subjected to other conditions ; at the one end it is heated to redness and at the other it is chilled ; and there is the further question of dangerous critical speeds should the rotors not be perfectly balanced. All these difficulties and many others that need not be mentioned, were, however, overcome. Thanks to the data previously obtained on these questions, and thanks to the special steels that the metallurgical experts had already produced, it was possible, without going through a process of trial and error to supply the aviation apparatus in a very reliable form, in fact much more reliable than the author had anticipated.

The arrangement possesses perfect flexibility ; it is merely necessary for the pilot to close the exhaust cut-out gradually in order to accelerate the compressor and the motor to a greater or less degree from the minimum, which corresponds to the cut-out completely opened (the motor then runs as though there were no turbo-compressor), up to the maximum speed when the cut-out is completely closed. In the latter position a sort of automatic regulation of speed takes place.

The diagram shown in Fig. 4 gives the speeds of rotation of a turbo-compressor, of the 175-h.p. type, which are necessary for restoring the ground level atmospheric pressure at various altitudes. The output of the turbo-compressor is plotted as abscissæ, in grammes per second ; the power of the motor is directly proportional to this output as also is the speed of the aeroplane for flight at constant altitude. The fall of atmospheric pressure is plotted as ordinates, in millimetres of mercury at the various altitudes. The horizontal lines correspond to altitudes of 1 km., 2 km., up to 8 km. for normal barometric height, and the temperatures are marked alongside. The chain-dotted line corresponds to the maximum output of the turbo-compressor. From this curve it will be seen that in order to obtain the same pressure as at ground level, for a motor of nominal 200 h.p. :—

For Z = 1 km. the speed required is 13,300 r.p.m.
Z = 2 km. the speed required is 18,500 r.p.m.
Z = 3 km. the speed required is 22,200 r.p.m.
Z = 4 km. the speed required is 25,400 r.p.m.
Z = 5 km. the speed required is 29,400 r.p.m.
Z = 6 km. the speed required is 33,100 r.p.m.

It would not be prudent to exceed the speed of 30,000 r.p.m. appreciably ; the coefficient of safety would then fall to too low a value. If at low altitudes, the exhaust cut-out were closed the turbo-compressor would give too high a pressure, a pressure which the actual aeroplane motor is not capable of withstanding. This is to be regretted, because it would have afforded a means for obtaining an appreciable increase in the initial power. Designed in the first instance, for a motor of 175 h.p., at the beginning of 1917, the turbo-compressor was tested thoroughly in the works, systematically, by means of an experimental arrangement enabling the running conditions to be varied far outside the range of those that would be met with in practice on the aeroplanes. Thus, in trials at overload, the turbo-compressor was made to revolve at speeds up to 53,000 r.p.m., giving a peripheral speed of 670 m. per second at the tips of the compressor. The turbo-compressor drawing from a reservoir and

Fig. 3. RATIO $\frac{p_1}{p_0}$ PLOTTED FOR VARIOUS VALUES OF τ IN EQUATION $\tau = \eta \frac{T_1}{T}$.

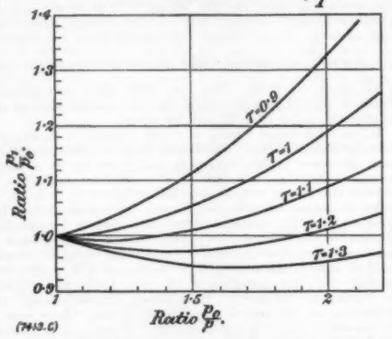
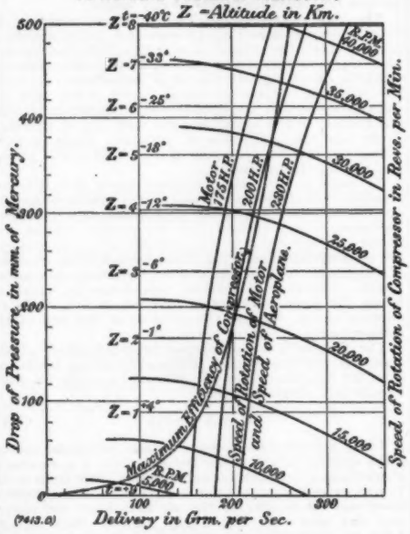


Fig. 4. SPEEDS OF ROTATION OF TURBO-COMPRESSOR FOR RESTORING PRESSURE OF ADMISSION AIR TO NORMAL 760 MM. OF MERCURY.



compressing to the atmospheric pressure, produced a vacuum of about 60 cm. of mercury ; that is to say, it has a compression ratio greater than 4·5. After these trials at the works, the turbo-compressor was handed over to the Aeronautical Technical Section, which took charge of it. Under the direction of Commanders Caquot and Martinot-Lagarde, to whom the author wishes to express his particular thanks, the trials were first made at ground level (at the high-level station at Galibier, 2,500 m.) in August, 1917, and then on board a trial aeroplane, by Lieutenants Sadi-Lecointe and Canivet. The manufacture in quantity had been already commenced in a works that had been specially built for the object by the company engaged in the manufacture of the Rateau turbines, when the war came to an end.

(To be continued.)

PROPOSED LARGE DANISH WIRELESS STATION.—A Government Commission which has been sitting for a couple of years has now handed in its report, recommending the erection of a radio station, to be constructed and worked by the Ministry for Public Works, and able to maintain wireless connection across the Atlantic. The question has been under discussion for several years, and at one time it was contemplated to arrange for co-operation with big wireless stations in neighbouring countries. As to the system there has been a natural desire to adopt the Danish Valdemar Poulsen system, but two members of the Commission hold that the choice should be postponed, pending further and more definite results.

PROPORTIONS AND BLOCK COEFFICIENTS OF MERCHANT STEAMERS.*

By W. J. LOVETT, Member.

1. LLOYD'S REGISTER for 1921–22 contains particulars of about 28,500 steamers, and their analysis on a speed basis is given in Table I.

TABLE I.—Not exceeding 13 knots, 27,220 ; over 13 knots and under 16 knots, 737 ; 16 knots and under 19 knots, 361 ; 19 knots and under 22 knots, 77 ; 22 knots and over, 34.

From these figures it may be assumed that about 3 per cent. of the merchant steamers of the world are engaged primarily in the passenger trade and the remaining 97 per cent. are cargo carriers.

2. An individual analysis has been made for about 700 vessels of 15 knots' speed and over. The dimensions of each were proportioned to a common length of 400 ft., and the comparative mean breadths at varying speeds are shown in Table II, omitting such special vessels as American river steamers. The analysis is given for two groups, viz., vessels of less length than 400 ft. and vessels exceeding 400 ft. in length.

TABLE II.

Length.	Mean Proportionate Breadths for Length of 400 Ft.			
	15 to 17 Knots.	17 to 19 Knots.	19 to 21 Knots.	21 Knots and Over.
	ft.	ft.	ft.	ft.
Vessels under 400 ft. ..	51·4	50·2	49·4	48·5
Vessels over 400 ft. ..	48·0	47·0	46·5	44·5

It will be noted that there is a gradual reduction of beam as the speeds increase, and that the small steamers have adopted, or been forced to adopt, greater beam than the large steamers, and this increase becomes more marked when the vessels are considered on a $\frac{V}{\sqrt{L}}$ basis.

The market for, or the supply of, large steamers of 19 knots or over is limited, as there are only 26 vessels of that speed over 400 ft. in length, whereas there are 27 vessels under 300 ft., and 58 between 300 ft. and 400 ft. that are capable of this speed ; so that the fast steamers of our mercantile navies are preponderatingly of short length. Table III has been prepared to illustrate this feature.

TABLE III.

Speed.	Number of Vessels.					
	Under 200 Ft. Long.	200 to 300 Ft.	300 to 400 Ft.	400 to 500 Ft.	500 to 600 Ft.	Over 600 Ft.
Above 23 knots ..	0	3	10	0	0	4
21 to 23 knots ..	0	6	24	0	4	4
19 to 21 knots ..	0	18	24	3	9	2
18 to 19 knots ..	1	24	17	8	15	7
17 to 18 knots ..	3	30	26	25	29	9
16 to 17 knots ..	4	53	39	38	27	6
15 to 16 knots ..	9	61	40	78	28	1
Total	17	195	180	152	112	33

A comparison is made in Table IV between a summary of Table III and a similar analysis prepared from Lloyd's Register for 1914. This shows that at present there is a shortage of almost 200 steamers of 15 knots' speed and over as compared with the 1914 returns, which means that the world's existing fleet of fast merchant steamers is 20 per cent. less in numbers than pre-war standard.

TABLE IV.

Speed.	Number of Vessels.	
	1914–15.	1921–22.
Above 23 knots	23	17
21 to 23 knots	46	38
19 to 21 knots	90	56
18 to 19 knots	101	72
17 to 18 knots	125	122
16 to 17 knots	209	167
15 to 16 knots	284	217
Total	878	689

3. Excess of beam involves excess of power in fast vessels where the wave-making resistance is a dominant feature, but in cargo carriers the resistance is largely frictional, and dimensional proportions may be modified within wide practical limits without detriment to the propulsive efficiency. Existing cargo tonnage has a mean breadth of about $\frac{1}{7}$L plus 11 ft., but the published returns of recently-built steamers show that the present practice favours increased beam in proportion to length, as is indicated in the list of some broad vessels given in Table V, which could be considerably extended.

* Paper read at the Paris summer meeting of the Institution of Naval Architects, July 6, 1922.

For convenience of analysis the beam of each vessel has been proportioned to a common length of 400 ft.

TABLE V.

Name of Vessel.	Length.	Beam.	Draught.	Beam for 400-Ft. Length.
	ft.	ft.	ft. in.	ft.
John D. Archbold ..	555	75·0	30 0	54·1
Keystone State ..	518	72·0	30 6	55·6
Amsterdam	476	65·7	—	55·2
Almelo	447·5	62·8	—	56·2
Ohio	445	61·2	26 9	55·0
Nagara	430	61·3	29 4	57·0
Agwimara	429	59·2	25 7	55·2
Brielle	402	58·3	—	58·0
P.L.M. 20	400	56·0	25 1	56·0
Burgerdijk	400	54·0	30 2	54·0
Boren	377	54·0	24 2	57·3
Assiout	370	51·2	24 0	55·3
Kedoe	367	51·5	23 2	56·1
Maplemore	365	51·0	23 7	55·9
Saint René	351	52·5	24 4	59·8
Digby	350	50·0	23 6	57·1
Urd	334	48·0	21 3	57·5
Sierra Morena	331	48·7	22 0	58·8
Kielehaven	327	47·3	20 5	57·8
Victor de Chavarri ..	312	48·0	20 2	61·5
Omana	303	46·2	19 3	60·9
Sebastian	303	43·0	19 10	56·7

Separating the larger of the above vessels from the smaller ones, then, for a common length of 400 ft. (1) Vessels 400 ft. and upward have mean proportionate beam of 55·6 ft.; (2) vessels under 400 ft. have mean proportionate beam of 57·9 ft. The Keystone State, a vessel of 518 ft. length, has a beam of $\frac{1}{10}$L. plus 20·2 ft. The Victor de Chavarri, a vessel of 312 ft. length, has a beam of $\frac{1}{10}$L. plus 16·8 ft., and the Nagara, a vessel of 430 ft. length, has a beam of $\frac{1}{10}$L. plus 18·3 ft.

4. The depth of water available at a port will determine the maximum permissible draught when entering the port, and, as all vessels entering any port are thus limited in draught, it follows that the proportions of beam to draught will vary considerably. For cargo carriers with erections extending over 60 per cent. of the length, the assigned freeboard draught is a fairly constant fraction of the depth and is only slightly modified by length, shear and block coefficient. Taking the same block coefficient, same proportions of deck erections, and same sheer ratio, then

draught = 0·83 depth for 350-ft. steamer.
= 0·81 depth for 400-ft. steamer.
= 0·79 depth for 450-ft. steamer.

If the draught of the vessel is limited, the depth for deadweight cargoes is fixed by the addition of draught and freeboard, but where the draught is not so limited the depth is fixed by the beam, in order to give a stable vessel under ordinary conditions of lading; and as increasing the draught is the cheapest way to obtain deadweight, this vessel will be the best paying for its owner. Stable proportions of depth to breadth will vary with the erections, but assuming 60 per cent. of the length to be covered by erections, then a stable depth may be taken as 0·63 beam. Dealing only with two dimensions, it will not lessen the cost if a vessel of ordinary proportions is made shorter and broader, because, although breadth is slightly cheaper to build than length, there must be a reduction in the block coefficient of the shorter and broader vessel. When, however, the adoption of the greater beam can be utilised to increase the depth, and consequently the draught, it does pay an owner to modify the dimensional proportions of his vessel, and the economical grades between the vessel of ordinary and extreme proportions are largely dependent on the permissible load draught. The limits of present-day practice may be stated as:—

Breadth = $\frac{1}{7}$ length plus 18 ft.
Depth = 0·63 of breadth.
Draught = 0·81 of depth (for 400 ft. length).

This gives a vessel 400 ft. by 58 ft. by 36 ft. 6 in. and 29 ft. 6 in. draught, and this maximum economic limit for hull cost of ratio of beam to draught is 1·97, but it is seldom practicable to have so deep a draught, and the mean proportionate breadth and draught of the vessels in Table IV may be stated on a 400-ft. length basis as 57 ft. by 25 ft. 9 in., or a ratio of 2·21 and a difference of 3 ft. 9 in. in the draught. An owner is therefore prevented from going to the limit of maximum economic proportions until the available depth of water at the various ports is made suitable for the increased load draught.

5. The determination of the block coefficient is usually a matter of comparison with similar vessels, but the publication of various model experiment results has suggested a manner of arriving at a maximum fullness of form compatible with economy of propelling power, and presuming in all cases a well-established tank form of model. The proceedings of the technical societies in this and other countries contain records of model experiments variously set out, and in most cases made to demonstrate some definite postulate. These available results, when applicable to cargo vessels, have been plotted to Froude's (K) and (C) values, and in each case a note was taken of the (K) speed value at midway on the first definite steepening of the (C) curve, denoting an increase in resistance ratio. This frequently occurred in 400-ft. to 450-ft. vessels at a (C) value of about 0·7, so that it may almost be inferred that cargo vessels of good tank form of model have their maximum speed for economical propulsion at that (K) value where the (C) curve crosses the 0·7 value datum. Many slow-speed forms have been tried in the tank to give smaller (C) values than 0·7 at the designed speed, although in these cases it is probable that the models could have been made fuller and better paying propositions for their owners, but there is undoubtedly a distinct range or latitude of fullness or fineness, and the owner must decide whether it pays him better to have a fine model and low engine power or a full model and high engine power.

The block coefficients in Table VI will enable a form to be designed suitable for the speed intended, but of course, a still fuller coefficient might be employed at the expenditure of an excess power and fuel consumption, and *vice versa*. These block coefficients are intended to be applied to vessels having midship coefficients within the limits of 0·96 to 0·99, and lengths within the limits of 350 ft. to 550 ft.

6. The results of detailed comparative calculations for various vessels are given in Tables VII, VIII and IX. In each table type A is a vessel of ordinary proportions having a beam of $\frac{1}{10}$L. plus 12 ft., and also of average draught. Type B has same draught but a beam of $\frac{1}{10}$L. plus 18 ft. Type C has the extreme beam of $\frac{1}{10}$L. plus 18 ft., but has the maximum depth for safe stability and the maximum draught for this depth. The depth in types A and B have been determined by the addition of the draught and freeboard. In all cases the vessels have plain cargo boat specifications and erections covering 60 per cent. of the length. The comparative indicated horse-power in each case is stated.

The hull cost, being chiefly dependent on the weight of steel, is comparatively shown as a percentage in all cases, and the basis figure of 100 is given to type A vessels of ordinary proportions and average draughts.

TABLE VII.

6,000 Tons Deadweight 10½ Knots Speed.

Item.	A.	B.	C.
Length	357 ft.	343 ft.	319 ft.
Breadth	47·7 ft.	52·3 ft.	49·9 ft.
Depth	27·25 ft.	27 ft.	31·42 ft.
Draught	23 ft.	23 ft.	26 ft. 3 in.
Coefficient	0·771	0·733	0·712
Displacement ..	8,630	8,630	8,500
I.H.P.	1,640	1,620	1,620
Cost of hull	100	100	93

TABLE VIII.

9,000 Tons Deadweight 11 Knots Speed.

Item.	A.	B.	C.
Length	408 ft.	393 ft.	372 ft.
Breadth	52·8 ft.	57·3 ft.	55·2 ft.
Depth	32 ft.	31·75 ft.	34·83 ft.
Draught	26 ft.	26 ft.	28 ft. 7 in.
Coefficient	0·782	0·75	0·737
Displacement ..	12,530	12,530	12,360
I.H.P.	2,400	2,370	2,360
Cost of hull	100	100	93

TABLE IX.

12,000 Tons Deadweight 11½ Knots Speed.

Item.	A.	B.	C.
Length	460 ft.	443 ft.	423 ft.
Breadth	58 ft.	62·3 ft.	60·3 ft.
Depth	35·25 ft.	34·83 ft.	38 ft.
Draught	28 ft.	28 ft.	30 ft. 4 in.
Coefficient	0·791	0·765	0·754
Displacement ..	16,900	16,900	16,660
I.H.P.	3,300	3,270	3,250
Cost of hull	100	100	94

Conclusions.—In vessels of $\frac{V}{\sqrt{L}}$ up to about 0·65, and trading generally in smooth water:—

(1) It is an advantage to increase beam if depth and draught can also be increased.

(2) It is no advantage to shorten and broaden a vessel if the draught is not increased.

(3) It is no disadvantage to increase beam if necessary for stability.

(4) Increased beam does not involve reduced speed nor increased power nor increased cost if displacement is unchanged.

(5) A minimum depth of channel of 32 ft. should be provided at all important seaports.

TABLE VI.

BLOCK COEFFICIENT.

$\frac{V}{\sqrt{L}}$	Length ÷ Breadth.																	
	6·5	6·6	6·7	6·8	6·9	7·0	7·1	7·2	7·3	7·4	7·5	7·6	7·7	7·8	7·9	8·0	8·1	8·2	8·3
0·70	0·647	0·653	0·659	0·664	0·670	0·676	0·681	0·686	0·691	0·696	0·701	0·705	0·710	0·714	0·719	0·723	0·728	0·732	0·737
0·69	0·653	0·659	0·665	0·671	0·676	0·681	0·686	0·691	0·696	0·701	0·706	0·711	0·715	0·720	0·724	0·729	0·733	0·737	0·742
0·68	0·660	0·666	0·671	0·677	0·682	0·687	0·692	0·697	0·702	0·707	0·712	0·716	0·720	0·725	0·729	0·734	0·738	0·742	0·747
0·67	0·666	0·672	0·678	0·683	0·688	0·693	0·698	0·703	0·708	0·712	0·717	0·721	0·726	0·730	0·735	0·739	0·743	0·747	0·752
0·66	0·673	0·679	0·684	0·689	0·694	0·699	0·704	0·709	0·713	0·718	0·722	0·726	0·731	0·735	0·739	0·744	0·748	0·752	0·756
0·65	0·679	0·685	0·690	0·695	0·700	0·705	0·709	0·714	0·719	0·723	0·727	0·732	0·736	0·740	0·744	0·749	0·752	0·757	0·761
0·64	0·686	0·691	0·696	0·701	0·706	0·710	0·715	0·720	0·724	0·728	0·732	0·737	0·741	0·745	0·749	0·753	0·757	0·761	0·765
0·63	0·692	0·697	0·702	0·707	0·711	0·716	0·721	0·725	0·729	0·733	0·737	0·741	0·745	0·750	0·753	0·757	0·761	0·765	0·769
0·62	0·698	0·703	0·708	0·713	0·717	0·722	0·726	0·730	0·734	0·738	0·742	0·746	0·750	0·754	0·758	0·762	0·765	0·769	0·773
0·61	0·704	0·709	0·714	0·719	0·723	0·727	0·731	0·735	0·739	0·743	0·747	0·751	0·755	0·758	0·762	0·766	0·770	0·773	0·777
0·60	0·710	0·715	0·720	0·724	0·728	0·732	0·736	0·740	0·744	0·748	0·752	0·755	0·759	0·763	0·766	0·770	0·773	0·777	0·780
0·59	0·716	0·721	0·725	0·729	0·733	0·738	0·741	0·745	0·749	0·752	0·756	0·760	0·763	0·767	0·770	0·774	0·777	0·781	0·783
0·58	0·722	0·726	0·731	0·735	0·739	0·743	0·746	0·750	0·754	0·757	0·761	0·764	0·767	0·771	0·774	0·777	0·781	0·784	0·787
0·57	0·727	0·732	0·736	0·740	0·744	0·748	0·751	0·755	0·758	0·762	0·766	0·769	0·772	0·775	0·778	0·781	0·784	0·787	0·790
0·56	0·733	0·738	0·741	0·745	0·749	0·752	0·756	0·759	0·763	0·766	0·769	0·772	0·775	0·778	0·781	0·784	0·787	0·790	0·793
0·55	0·739	0·743	0·747	0·750	0·754	0·757	0·761	0·764	0·767	0·770	0·773	0·776	0·779	0·782	0·785	0·788	0·791	0·794	0·796
0·54	0·744	0·748	0·752	0·755	0·758	0·762	0·765	0·768	0·771	0·774	0·777	0·780	0·783	0·786	0·788	0·791	0·794	0·797	0·799
0·53	0·749	0·753	0·757	0·760	0·763	0·766	0·769	0·772	0·775	0·778	0·781	0·784	0·786	0·789	0·792	0·794	0·797	0·799	0·802
0·52	0·755	0·758	0·762	0·765	0 768	0·771	0·774	0·777	0·779	0·782	0·785	0·787	0·790	0·792	0·795	0·797	0·800	0·802	0·805
0·51	0·760	0·763	0·766	0·769	0·772	0·775	0·778	0·781	0·783	0·786	0·788	0·791	0·793	0·795	0·798	0·800	0·803	0·805	0·807
0·50	0·765	0·768	0·771	0·774	0·777	0·780	0·782	0·785	0·787	0·790	0·792	0·794	0·796	0·799	0·801	0·803	0·806	0·808	0·810

BRITISH STANDARD SPECIFICATION AND SECTIONS FOR BULL HEAD RAILWAY RAILS.—The British Engineering Standards Association has just issued the revised British Standard Specification and Sections for Bull Head Railway Rails, Report No. 9, 1922, copies of which may be obtained for 1*s.* 2*d.*, post free, from the Secretary, 28, Victoria-street, Westminster, S.W. 1, or from Messrs. Crosby Lockwood and Son, 7, Stationer's Hall-court, E.C. 4. This is the second revision of the specification which was originally published in 1904, and it embodies alterations which experience has shown to be desirable to meet present-day requirements, among which are the following: Two classes of rails are now included, namely, ordinary carbon and higher carbon rails, and separate chemical analyses are specified for Bessemer and open-hearth steels. The position in the head of the rail from which the drillings and the test pieces for the chemical analyses and tensile tests are to be taken is now defined. In the falling weight test the use of crop ends is allowed, and the measurement of permanent set after the first blow has been omitted. The test is required to be carried out upon the British standard falling weight-testing machine, the specification for which is inserted as an appendix. The height of the drop for B.S. Section No. 90 has been reduced to 18 ft. The range of tensile breaking strengths for ordinary carbon rails has been increased to 42 tons to 53 tons per square inch, and a range of tensile strengths for higher carbon rails inserted. An arbitration clause has been included. The report is furnished with full-sized diagrams of the British standard bull-head rail sections ranging from 60 lb. to 100 lb. per yard, and on the diagrams approximate metric equivalents of the British measures have been given, but it is clearly laid down that the figures in British measures are to be regarded as the standard.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

GAS ENGINES, PRODUCERS, HOLDERS, &c.

175,012. A. C. Smith, Shepherds' Bush. Rotary Engines or Motors. (3 *Figs.*) November 2, 1920.—The rotary engine or motor according to the present invention comprises, in combination, an outer cylinder 1 having inlet and exhaust ports therein connected with induction and exhaust pipe 28, 29, respectively, a rotatable cylinder 7 mounted concentrically therein also having inlet ports 5a, 5c and exhaust ports 6a, 6c which co-operate with those in the outer cylinder. A spindle 12 free to rotate, is rotatably mounted within the cylinder 7; a pair of diametrically arranged internal vanes 16, 17 are carried on and within the rotatable cylinder and extend to the spindle and a pair of diametrically arranged longitudinal vanes 14, 15 are carried on the spindle and extend to the rotatable cylinder. Assuming the vanes 14, 15, 16, 17 to be in the positions shown in Figs. 2 and 3, a charge has been compressed between the two vanes 14, 16. This is ignited by a spark in the usual way, whereby the vane 14 is urged forward in the direction of the arrow and with it the

Fig. 1.

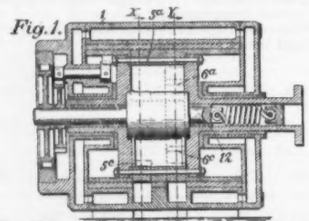


Fig. 2.

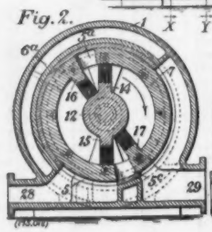
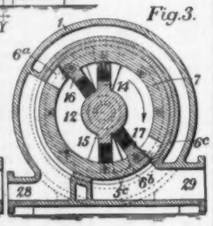


Fig. 3.

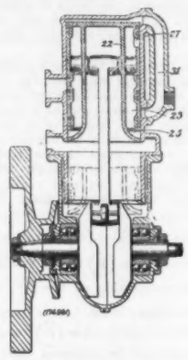


spindle 12; the vane 16 is unable to move backward by reason of its mass and the mass of the apparatus driven therefrom. During this movement, the vane 14 exhausts the burnt gases from the space in front of it through the ports 6c and 6b and the vane 17 moves forward a short distance. At the same time the movement of the vane 15 from the vane 17 draws in a fresh charge between the two vanes through the inlet ports 5 and 5c, and at the same time compresses the charge between the vanes 15 and 16. At the next explosion the charge compressed between the vanes 15 and 16 is ignited so that the vane 16 is moved forward, and with it the cylindrical member 7. The vane 15 is prevented from backward movement. During this operation the movement of the vane 16 exhausts the burnt gases in front of it through the ports 5a and 5b, and the movement of the vane 17 draws in behind it a fresh charge through the ports 6 and 6c and compresses the charge between the vanes 17 and 15. (*Sealed.*)

174,797. J. E Rees, Manchester. Internal-Combustion Engines. (4 *Figs.*) November 22, 1920.—This invention relates to auxiliary air valves for internal combustion engines of the kind comprising a valve automatically actuated by the movement of a perforated or gauze baffle located in the induction pipe or between the induction pipe and the carburettor, and influenced by the passage of the fuel mixture. According to the invention, a fitting *a* located between the induction pipe and the outlet pipe of the carburettor is formed with transversely-arranged pockets *e*, each having a central opening leading to the

mixture passage. Located in each pocket is a ball *e* forming a valve to close said passage. A light spring *f* is provided to maintain the valve normally on its seating. Within the mixture passage is a diaphragm *i* formed of perforated sheet metal or wire gauze having projections *j* thereon adapted to engage the balls *e*. The diaphragm is capable of a rising and falling movement under the influence of the flowing fuel mixture, and the arrangement is such that the rising movement of the diaphragm causes the projections *j* to push the ball valves *e* off their seatings and allow auxiliary air to enter the induction pipe. (*Sealed.*)

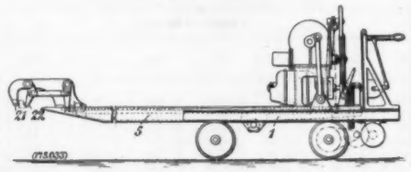
174,981. J. R. M. Stanfield, Cardiff, Wales, and J. F. Adye, Dinas Powis. Internal-Combustion Engines. (1 *Fig.*) October 4, 1920.—This invention relates to internal-combustion engines of the type which operates on a two-stroke cycle, and in which the charges of explosive mixture or air for combustion are compressed in the crank-chamber and delivered therefrom into the working cylinder by a transfer-conduit 31 which is outside the working cylinder and which is in constant communication with the space above the piston when at the inner end of its stroke. According to the present invention, an engine of the above-described type is provided with a piston 22 formed with an annular chamber or passage 23 inside its skirt and ports 26, 27 at each end of the skirt communicating with the chamber 23, and so spaced that when the lower port 26 passes beyond the cylinder wall at the end of the out stroke of the piston it com-



municates with the crank chamber, and the upper port 27 registers with the inlet end of the transfer conduit 31. A charge compressed in the crank chamber is then delivered through the lower port 26 into the annular chamber or passage 23 and thence out through the upper port 27 into the transfer conduit 31 and working cylinder. (*Sealed.*)

MINING, METALLURGY AND METAL-WORKING.

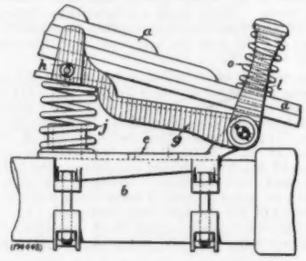
175,033. Stein and Atkinson, Limited, Westminster, London, and H. B. Higginbottom, Westminster, London. Transporting Apparatus. (6 *Figs.*) November 5, 1920.—This invention of transporting apparatus is particularly applicable for use in shops and works, such as steel works, for picking up an article at one machine, transporting the article to another machine and depositing it on the machine ready for a subsequent



operation. Transporting apparatus, in accordance with this invention, comprises a truck or carriage 1, a pivotally mounted platform 5 thereon, gripping means 21, 22 mounted on the platform and traversable from one end towards the pivotal point and *vice versa*, and an electric motor and gearing mounted on the platform to actuate the gripping means, to traverse them and to move the platform about its pivotal point. (*Sealed.*)

MOTOR ROAD VEHICLE.

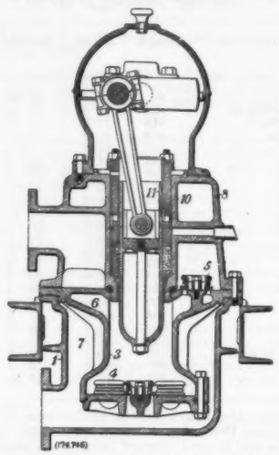
174,448. H. S. Nowell, Stretford, Manchester. Motor Vehicles. (5 *Figs.*) October 28, 1920.— This invention refers to auxiliary springing devices for motor vehicles, and provides an attachment for applying to the ends of existing springs of the laminated type to provide additional spring support when the existing springs are loaded above their normal carrying capacity without unduly interfering with the ordinary spring action of the same. According to the invention, the apparatus comprises a bracket like fitting or carrier *c* adapted to be attached to the chassis or axle *b*, and having a pivoted sliding member *g* mounted thereon. The movable member *g* is adapted to engage one side of the usual laminated spring *a*, an anti-friction roller



or ball *h* preferably being interposed, and a comparatively strong spring *j* being provided to force the free end of the movable member *g* into engagement with the laminated spring, the arrangement being such that with excessive loads the auxiliary spring takes part of the load. The pivotal connection of the bracket *c* and member *g* is preferably arranged to lie at the extremity of the usual laminated spring and a member *l* is pivoted on or adjacent to the pivot axis of the member *g* adapted to pass around the laminated spring to form an abutment for a compression spring *o* adapted to bear on the tail end of the laminated spring *a* to serve as a rebound spring. (*Sealed.*)

PUMPS.

174,746. H. C. Clark, Westminster, London, and The "B.C.B." Pump Manufacturing Company, Limited, Westminster, London. Pump. (4 *Figs.*) November 3, 1920.—According to this invention, the pump consists of a base casting 1 positioned within which is a barrel 3 which carries the suction valves 4 and the delivery valves 5. Passages 6 are formed in the flared portion of the casting to lead the water from the barrel 3 to the delivery valves 5. The annular space 7 between the two castings 1, 3 forms the suction air vessel. A dome-shaped casting 8 rests upon barrel casting 3, the three castings 1, 3, 8 being bolted together by one set of bolts or studs, so that by removing the bolts the whole pump can



be readily opened out without disturbing the plunger and driving mechanism. The casting 8 forms the delivery air vessel, and possesses a central portion or cylinder 10 which contains the plunger 11. (*Sealed.*)

SHIPS AND NAUTICAL APPLIANCES.

172,457. J. W. M. Hall, Dalmuir, and G. McIntosh, Glasgow. Caulking Tools. (3 *Figs.*) September 29, 1920.—This invention particularly relates to that type of caulking apparatus which is adapted to travel along the seam to be caulked and which carries the caulking knife, operated by means of a pneumatic caulking tool or hammer carried by the apparatus, to drive the packing into the seam to be caulked. The aforesaid type of apparatus comprises a carriage member provided with travelling wheels and guide rollers. The wheels travel on the deck on each side of the seam to be caulked while the guide rollers travel in the seam in front of and behind the caulking knife which is operated by a pneumatic caulking tool or hammer carried by the carriage member. According to this invention, apparatus of the above type consists of a carriage member which comprises two similar castings 1, each provided with a pair of lugs 5 at both ends and having axle bolts 2 passing through the lugs on which

Fig. 1.

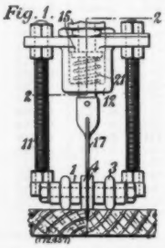
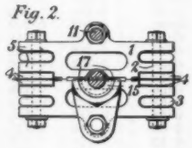


Fig. 2.



travelling wheels 3 and guide rollers 4 are mounted. The guide rollers 4 are arranged centrally between the similar castings 1 and are adapted to travel in the seam to be caulked while the travelling wheels 3 are arranged one on each side of each guide roller 4 and are adapted to travel upon the deck on each side of the seam to be caulked. The two similar castings are secured together by the axle bolts 2, so that there is a space between same through which the caulking knife 17 operates. Located centrally above the space and carried by two upright supports 11, fitted one to each of the castings, is a pneumatic tool carrying cylinder 12. The barrel of a pneumatic caulking tool 15 is secured in the tool-supporting cylinder 12, the tool being operated through the bottom end of the cylinder. The caulking knife 17, which enters the seam during the operation of caulking, is secured at its upper end to the pneumatic tool 15. A spring 21 is provided to return the tool after each downward blow has been given by the piston of the pneumatic caulking tool. (*Sealed.*)

171,932. C. Law, Bo'ness. Steering Ships. (7 *Figs.*) August 17, 1920.—Consists in using submersible towed bodies, such as paravanes in pairs, for emergency steering of ships, each towed body having either one or two towing wires. When one wire H, Fig. 1, is used for each paravane, steering is effected by hauling in one wire on the port or starboard side and paying out the wire of the paravane on the other side. When two wires

Fig. 1.

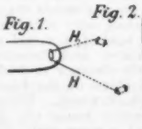


Fig. 2.

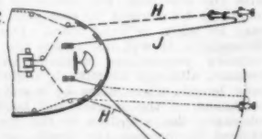
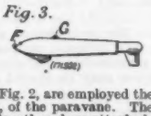


Fig. 3.



H, J, Fig. 2, are employed they are attached to the points F, G, Fig. 3, of the paravane. The port and starboard wires J are of equal length and are attached at fixed points to the ship, whereas the wires H are led in board to the main steering chains, or to a winding medium, such as a winch, so as to be adjustable relatively for steering as shown. More than one pair of towed bodies may be employed. (*Sealed.*)